MINERALS YEARBOOK

METALS AND MINERALS

Volume I

MARCH 3, 1849

UNITED STATES
DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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UNITED STATES DEPARTMENT OF THE INTERIOR • Bruce Babbitt, Secretary

BUREAU OF MINES

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for Native American reservation communities and for people who live in Island Territories under U.S. administration.

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Preface

This edition of the Minerals Yearbook discusses the performance of the worldwide minerals and materials industry during 1994 and provides background information to assist in interpreting that performance. Content of the individual Yearbook volumes follows:

Volume I, Metals and Minerals, contains chapters on virtually all metallic and industrial mineral commodities important to the U.S. economy. This volume also contains chapters on Survey Methods, a Statistical Summary of Nonfuel Minerals, and Trends in Mining and Quarrying.

Volume II, Area Reports: Domestic, contains chapters on the minerals industry of each of the 50 States and Puerto Rico. This volume also contains a chapter on Survey Methods, and a Statistical Summary of Nonfuel Minerals. A Directory of State Geologists and other Minerals information contacts for all 50 States and Puerto Rico, updated in January, 1996, is included at the end of this publication.

Volume III, International Review, contains the latest available mineral data on more than 190 foreign countries and discusses the importance of minerals to the economies of these nations. The reports also incorporate location maps, industry structure tables, and outlook sections.

This is the last edition of the Minerals Yearbook to be published under the banner of U.S. Bureau of Mines, which closed in January 1996. Future editions will be published by the Office of Minerals Information, U.S. Geological Survey, MS 984, Reston, VA 22092. Constructive comments and suggestions for improvements from readers may be forwarded to this address.

To acknowledge the accomplishments of the U.S. Bureau of Mines over its 85 year life, a brief history of the organization precedes the main text of the Yearbook. On behalf of all past Bureau of Mines Directors, I would like to dedicate this edition of the Minerals Yearbook to the memory and professionalism of all its employees that have served it so well since its founding in 1910.

Rhea Lydia Graham, Director

Acknowledgments

Volume I, Metals and Minerals, of the Minerals Yearbook presents data on more than 80 minerals and materials that were obtained as a result of the information gathering activities of the U.S. Bureau of Mines.

The collection, compilation, and analysis of domestic minerals industry data were performed by the staffs of the Division of Mineral Commodities and the Division of Statistics and Information Services. Statistical data were compiled from information supplied by mineral producers and consumers in response to canvasses, and their responses are gratefully appreciated. Information obtained from individual firms by means of the U.S. Bureau of Mines canvasses has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonproprietary sources or when permission of the respondent has been granted. The chapters on "Survey Methods" and "Statistical Summary of Nonfuel Minerals" discusses in greater detail procedures for canvassing the minerals industry and the processing and evaluation of these data. Other information appearing in this volume was obtained from the trade and technical press, industry contacts, and additional sources; this cooperation is gratefully acknowledged.

Statistics on world production were compiled in the Division of Statistics and Information Services and Division of International Minerals from numerous sources, including reports from the U.S. Department of State. U.S. foreign trade data were obtained from reports of the U.S. Department of Commerce, Bureau of the Census. The U.S. Bureau of Mines also was assisted by numerous cooperating State agencies.

Ronald F. Balazik
Chief, Division of Mineral Commodities

THE HISTORY OF THE U.S. BUREAU OF MINES

By William S. Kirk

Introduction

This history was included in this volume because it was the last Minerals Yearbook published by the U.S. Bureau of Mines (USBM). The USBM ceased to exist in fiscal year 1996. This was written to provide a brief account of why and how the USBM was established, what has happened in the intervening 85 years, and to report some of its major accomplishments. The author wishes to thank all those who assisted in the creation of this chapter by providing material or reviews. Special thanks go to those USBM employees who, although they were soon to be unemployed, unfailingly responded to the author's requests for help. Future editions of this annual report were to continue to be published under the banner of the U.S. Geological Survey (USGS).

Creation and Organizational History

For some years before 1910, there were calls from many quarters to create in the Federal Government a bureau that would collect, evaluate, and disseminate scientific, technologic, and economic data of value to the mineral industries. The American Mining Congress, for example, proposed the creation of a Federal Department of Mines at its 1896 annual convention. The conservation movement also envisioned a federal role in helping the Nation use its mineral resources responsibly. Concern over the waste of both human and natural resources was reflected in the President's 1907 recommendation that a USBM be established in the Interior Department. Congress, however, did not act on this until a series of disasters in the Nation's coal mines had focused public attention on the loss of human life. These disasters took more than 3,000 lives in 1907 alone. There were 361 coal miners killed in Monongah, WV, on December 6, 1907; 239 killed 2 weeks later at Jacobs Creek, PA; 154 killed at Marianna, PA, November 28, 1908; and 259 killed at Cherry, IL, on November 13, 1909.

The USGS earlier had established a close relationship with the mining and mineral industries through the preparation and publication of its annual report on *Mineral Industries of the United States*. The USGS was also making studies in important mining areas. In 1899, the USGS Director recommended the establishment of a Division of Mines and Mining and, in 1904, Congress appropriated funds for analyzing and testing the coals of the United States. This led to the formation of the technologic branch, headed by Dr. Joseph A. Holmes, a former North Carolina State Geologist and university professor. On May 16, 1910, Congress passed the Organic Act (Public Law 179) establishing the USBM. The act authorized the Secretary of the Department of the Interior to transfer to the new bureau the types of investigations heretofore conducted by the technologic branch of the USGS together with the pertinent personnel, equipment, and property. The USBM became functional on July 1, 1910. Shortly thereafter, Dr. Holmes was appointed its Director and served until his death in July 1915.

Seeking to ensure the future success of the USBM, Dr. Holmes took up the serious problem of high mortality rate in U.S. mining. His goal was that a reduction in the rate would stand as the new bureau's first major achievement. Under his direction, significant progress was made in perfecting methods for saving lives in mine accidents and for lessening the dangers to which underground workers were exposed. Dr. Holmes authored the slogan "Safety First," making it the watchword of the USBM mission.

Dr. Holmes' death was attributed to his frequent travels into areas where only trained rescue crews should go to visit coalfields in which disasters had occurred. This, his colleagues thought, overtaxed his strength and seriously affected his health. Dr. Holmes believed, however, that the arduous traveling was necessary to maintain an effective educational campaign for the safety of miners and the advancement of U.S. mineral industries, and he did not spare himself in the long and wearing work. In the end, Dr. Holmes was remembered as a dedicated, indefatigable campaigner for the cause of safety among miners.

As defined in the Organic Act, the scope of the USBM was extended into the technical processes of production and use, including mineral technology and metallurgy. In addition to these efforts, the testing of fuels, and the investigation of mine explosions, the USBM was authorized to investigate the methods of mining, and in particular the safety of miners, and the appliances best adapted to prevent accidents; the possible improvement of conditions under which mining operations were conducted; the treatment of ores and other mineral substances; the use of explosives and electricity; and the prevention of accidents.

It is difficult to imagine the application of a technologic and safety program to an industry organized for profit, as was the mineral industry in the United States, without an understanding of that industry's place in the national economy. Nevertheless, the Organic Act did not specify economics or statistics as within the province of the new USBM's duties. From the beginning, the Director recognized the value of such data and, in his first annual report (for fiscal year 1911), set forth the need for statistical analysis of mineral problems and economic evaluation of the mineral industry.

The USBM's scope was extended in 1913 by an amendment to the Organic Act (Public Law 386). This amended act added significantly to the duties, which included the following functions:

> To conduct inquiries and scientific and

technologic investigations concerning mining and the preparation, treatment, and utilization of mineral substances with a view to improving health conditions, and increasing safety, efficiency, economic development, and conserving resources through the prevention of waste in the mining, quarrying, metallurgical, and other mineral industries.

To inquire into the economic conditions affecting these industries.

To investigate explosives and peat.

To investigate the mineral fuels and unfinished mineral products belonging to or for the use of the United States, on behalf of the Government, with a view to their most efficient mining, preparation, and use, and

To disseminate information concerning these subjects.

In 1915, the Congress passed an act that authorized the establishment of 7 mine-safety stations and 10 mining experiment stations; by 1921, the number of mining experiment stations had been increased to 13 and, in addition, 12 field offices had been established.

Following the passage of the 1920 Leasing Act (Public Law 126), the USBM acquired the responsibility of supervising mining operations on public lands.

Nineteen twenty-five was an active year for the USBM. First, the USBM was moved from the Department of the Interior into the Department of Commerce. On June 4, 1925, President Calvin Coolidge issued an executive order creating the Department of Commerce and transferring the USBM and its employees, except those involved in oil-leasing work, into the new department, effective July 1, 1925. The purpose of the transfer was to permit a closer coordination of the activities of the USBM with the bureaus in Commerce whose activities were related. In 1934, the USBM was returned to the Department of the Interior by another executive order, signed by President Franklin D. Roosevelt.

Second, the USBM entered the field of mineral commodity statistics, as the Division of Mineral Resources of the USGS was transferred to the USBM, thus making the USBM the principal collector of mineral statistics. From then through the 1940's, the data collection program was accelerated because of the broadening of the USBM's own interest in the activities that follow mineral extraction and the increase in demand for minerals data, particularly by defense and emergency agencies.

Third, the USBM acquired the helium program. *(See figure 1.)* The USBM was directed to "conserve, produce, and exploit helium gas, a mineral resource pertaining to the national defense." The USBM was the world's only large-scale producer of helium until 1961. Major output after World War II was for a variety of uses including the space program. Five extraction plants were operated and, starting in 1963, much of the helium was recharged underground for future use.

Although the USBM's early research helped reduce the mine fatality rate, disasters continued to take a serious toll. The USBM's 1910 Organic Act strictly prohibited it from inspecting mines; adoption of its technical recommendations was strictly voluntary. By the late 1930's, the growing influence of the labor movement and the more expansive New Deal philosophy of Government had created a new context for the mine safety issue. Government's role was to go beyond research and training.

The Coal Mine Inspection Act of 1941 authorized the USBM to enter and inspect mines and recommend corrective actions. In 1952, Federal mine inspectors were given limited enforcement power to prevent major disasters. Critics insisted that wasn't enough. The death of 78 miners in an explosion at Consolidation Coal's No. 9 Mine in Farmington, WV, caused Congress to pass the Federal Coal Mine Health and Safety Act of 1969 (Public Law 91-173). That act put real teeth in Federal safety enforcement, setting up procedures for developing mandatory standards, and called for expanded health and safety research. This legislation directed that the USBM conduct the research necessary to eliminate coal mining hazards and/or provide alternate means of mining that reduce the risks of health impairment, injury, or death. The Federal Coal Mine Safety and Health Amendments Act of 1977 (Public Law 95-164) provided for the first time a single piece of comprehensive legislation for both coal and metal/nonmetal mining operations and extended the research mandates of prior legislation to all segments of the mining industry.

At different times in its history, large portions of the USBM were transferred to other agencies. The USBM's success in developing and introducing new safety technologies had always depended on a close cooperative relationship with industry. Industry officials attended USBM demonstrations and opened their mines to USBM scientists for testing new equipment and techniques. That close relationship seemed too close to some. Critics saw the USBM as an "industry-controlled agency" called upon to regulate its controller. A potential conflict of interest existed. In 1973, because of such concerns, the Secretary of the Department of the Interior separated the mining regulatory function from the mining research function by creating the Mining Enforcement and Safety Administration (MESA). About 3,000 people, plus facilities, were transferred from the USBM to MESA.

MESA was given responsibility for:

Enforcing coal-mine and metal and nonmetal mining health and safety regulations.

Assessing penalties for violations of mine health and safety laws.

Providing education and training in mine health and safety.

Developing mandatory health and safety standards.

The responsibility for the mining research, development, and demonstration function, continued to reside in the USBM. MESA was later to become the Mine Safety and Health Administration (MSHA) of the Department of Labor.

In 1960, the Office of Coal Research was spun off from the USBM and established in the Interior Department to "develop new and more efficient methods of mining, preparing, and utilizing coal." In late 1974, this office was absorbed into the newly created Energy

Research and Development Administration (ERDA), which was later to become part of the Department of Energy. The energy research centers of the USBM were transferred to ERDA in 1974.

A number of units and programs were created over the years to perform specific functions. The USBM had conducted international activities since its creation. During World War II and into the 1950's, the focus of the USBM's resource assessment and basic research programs shifted to the "strategic and critical" minerals and materials required to support the defense and industrial needs of a growing economy. By definition, a "strategic" material was one that was not available in adequate supply domestically and a "critical" material was one needed for national defense. In recognition of the growing importance mineral resources played in the domestic economy, the USBM established a separate international program in 1961.

In support of this new international role, the USBM, in cooperation with the Department of State, established a Minerals Attache program to report on key mineral resource developments in the major mineral producing regions of the world. *(See figure 2.)* At its peak, the Mineral Attache program was staffed by USBM mineral professionals in 12 American Embassies worldwide. The Attaches were an important first-hand source for the USBM in assessing the quality and availability of international mineral resources and provided technical advice and commodity market analysis to U.S. mining companies and local companies seeking mineral development opportunities in these regions.

In the early 1970's, political and budget considerations led the Secretary of State to convert the USBM-staffed Minerals Attache program to a Foreign Service Officer-staffed "Regional Resource Officer" (RRO) program. The RRO program was then run by the Department of State in consultation with a USBM/USGS advisory board. At the time of the USBM's closure, there were 10 RRO's posted to American Embassies in Brussels, Canberra, Caracas, Jakarta, Johannesburg, Mexico City, New Delhi, Rio de Janeiro, Santiago, and Tokyo.

The USBM maintained a core of approximately 30 multidisciplinary, multilingual country specialists to prepare a definitive annual survey of mineral industry activities in more than 160 countries. Published as the international volume of the USBM *Minerals Yearbook*, it was widely recognized as the most comprehensive work of its type.

A Division of Mineral Information Systems was created in 1979 to foster the increased use of computer and data base technology and to enhance statistical standards in the Automated Minerals Information System (AMIS).

It evolved into the Division of Statistics and Information Services in 1990 as part of a USBM restructuring effort to consolidate and better coordinate a variety of support and service functions dispersed throughout the Information and Analysis Directorate. These functions included data collection, publications, and statistical activities, as well as information systems and data dissemination. USBM data covered 100 mineral commodities and more than 168 countries and included information on exploration, development, reserves, capacity, prices, production, processing, consumption, trade, inventories, and recycling.

The land and mineral resources program, as it was at the time of the USBM's closure, had developed from the USBM wartime minerals production programs of the World War II and Korean War eras. Implemented by a staff of mining engineers, earth scientists, economists, and analysts in regional Field Operations Centers in Denver, CO, Spokane, WA, and Anchorage and Juneau, AK (an eastern Field Operations Center in Pittsburgh, PA was closed in 1981) and a Washington, DC, headquarters office, this program provided scientific and economic advice for the national debate over how to achieve balance between potential economic uses of public lands versus the preservation of natural values since passage of The Wilderness Act in 1964.

Over the years, the USBM played a major role in advising and assisting the Nation's policymakers in their efforts to address mineral and material resource issues. The policy function within the USBM took many forms. In the early years, such policy assistance was provided by the Director or his immediate staff. Later, this responsibility was focused under either the chief economist, the chief scientist, or chief mining engineer, depending upon the organizational structure at that time. In the mid-1970's, the USBM began incorporating into its headquarters function offices responsible for policy issues. By the late 1970's, the USBM had an Assistant Director for Policy. Then in the 1980's, a Division of Policy Analysis was established. In the late 1980's, as environmental and regulatory issues began having a greater affect on the mining and minerals industries, the USBM established an Office of Regulatory Projects Coordination. In the 1990's, the Office of Regulatory Projects Coordination was merged with the Division of Policy Analysis to become the Division of Regulatory and Policy Analysis. Over the last score of years prior to publication of this chapter, the structure had evolved from one staffed almost exclusively by economists to one of a multidisciplinary nature.

In 1970, the USBM began the State Liaison program to improve the quality of Federal minerals information at the State level. Under this program, 39 highly trained specialists were stationed in individual States to serve as Federal contacts, establishing relations with State and local governments, reporting to USBM headquarters on the overall state of mining and related industries within their assigned areas, calling attention to the wealth of material available from the USBM, and filling requests for USBM data and research material. The State Liaison Officers (SLO's) prepared the chapters of the *Minerals Yearbook* that covered their individual States, sometimes in conjunction with State offices. Other Liaison Officer duties included serving on State Government panels; reviewing proposed legislation on mine safety and mine reclamation; meeting with college faculty members to plan research projects; lecturing on mineral matters before various groups; arranging for and conducting tours of mines and similar points of interest for Federal, State, and local officials whose responsibilities required a knowledge of mineral industry activities; and advising job applicants on career opportunities within the USBM and the mineral industry.

U.S. Bureau of Mines
Directory of Directors

In its 85-year history, the USBM had only 19 directors. At the end of the USBM's existence, any employee with 30 years of service would have worked under one-half of them. The list of directors and their dates of tenure were as follows:

Joseph A. Holmes	1910-15
Van H. Manning	1915-20
Frederick G. Cottrell	1920
H. Foster Bain	1921-25
Scott Turner	1925-34
John W. Finch	1934-40
Royd R. Sayers	1940-47
James Boyd	1947-51
John J. Forbes	1951-55
Marling J. Ankeny	1956-64
Walter J. Hibbard, Jr	1964-68
John F. O'Leary	1968-70
Elburt F. Osborn	1970-73
Thomas V. Falkie	1974-77
Roger A. Markle	1978-79
Lindsay D. Norman, Jr	1980-81
Robert C. Horton	1981-87
TS Ary	1988-93
Rhea Lydia Graham	1994-96

Directors, First and Last

Joseph Austin Holmes, the first Director of the USBM, was born at Laurens, SC, on November 23, 1859. In 1881, he graduated from Cornell University with the degree of B.Agr., where he specialized in geology, chemistry, metallurgy, and physics. He was professor of geology and natural history at the University of North Carolina during 1882-91, and, in the latter year, was appointed state geologist. In 1904, the President appointed Dr. Holmes chief of the laboratories for testing fuel and structural materials at the USGS. Subsequently, he became chief of the technological branch. He was appointed by President Taft as the Director of the USBM upon its formation in 1910.

Under his management, new methods were perfected for preventing mine accidents. He equipped a model mine for testing explosions at Bruceton, PA, and in October 1911, organized the first national mine safety meeting. He was responsible for the establishment of Federal and State rescue stations in the coal and metal mining regions and the equipping of railroad cars as mobile safety and rescue stations. His most important discovery was that dust from bituminous coal was more dangerous than firedamp (methane) and, contrary to theory, would cause an explosion without the presence of gas. He was a member of the American Institute of Mining Engineers, and a fellow of the American Association of the Advancement of Science, and the Geological Society of America. The honorary degree of LL.D. was conferred upon him by the University of North Carolina and that of D.Sc. by the University of Pittsburgh. He died in Denver, CO, on July 12, 1915.

Rhea Lydia Graham, a geologist with a background in environmental consulting and engineering, was sworn in as the 19th director of the USBM on October 17, 1994. With her extensive experience in the minerals industry as an administrator in both the public and private sectors, she led the USBM with hard work, dignity, and pride.

As a senior scientist with Science Applications International Corporation in Albuquerque, NM, she worked with Government agencies on reinvention efforts. She assisted the U.S. Department of Energy in environmental regulatory compliance for the Waste Isolation Pilot Plant in Carlsbad, NM.

From 1988-91, Ms. Graham provided expertise in preparing for environmental compliance audits of the hazardous and mixed waste facilities at Lawrence Livermore National Laboratory, Lawrence Berkeley Laboratory, and Idaho National Engineering Laboratory.

From 1991-93, Ms. Graham served as director of the Mining and Minerals Division of the State of New Mexico Energy, Minerals, and Natural Resources Department. She administered the Title IV and Title V Programs for coal mine reclamation under the Surface Mining Control and Reclamation Act where she was responsible for administration and enforcement of permitted coal mine operations, safeguarding and protection of health and the environment under Abandoned Mine Land funds, and administration of grants and subcontracts to accomplish program goals. The Division also included the Mine Registration and Geological Service Bureau, which administered the State mine registration and safeguarding program and compiled and published mineral resources data for use by all State agencies. During her tenure, a hardrock mine reclamation law was passed by the New Mexico Legislature for administration by this Division.

She had experience with private-sector consultants such as Deuel and Associates, Inc. of Albuquerque, NM, and CH2M Hill, of Portland, OR, where engineering geology and environmental compliance were her primary projects, and Exxon Company USA, of Houston, TX. Ms. Graham also worked in the public sector as a research scientist in engineering geology for the Agriculture Department's Forestry Sciences Laboratory in the Pacific Northwest. She served on National Research Council committees for the National Academy of Sciences (Ground Failure Hazards: 1986-90; Research of the USBM: 1994).

Under her leadership and management, she continued the focus of a major reinvention effort that addressed both the recommendations of Vice President Gore's National Program Review and the relevancy of the USBM's programs. The last year of the USBM was a critical time for the agency that for 85 years had played a vital role in helping the Nation solve its mineral-related problems involving environmental and economic goals as well as issues of worker health and safety.

Ms. Graham came to the USBM with a rich personal history. Mining had influenced her family for almost 100 years. Her father's family had lived in Gibson County, IN, since before the Civil War, and many of her relatives were still active farmers there. Since the early 1900's, they had augmented their farming income by working in the nearby coal mines.

She obtained an A.B. in geology from Bryn Mawr College in 1974 and an M.A. in oceanography from Oregon State University in 1977. She was a registered geologist, a registered engineering geologist, and a registered environmental assessor.

When the final chapter of the USBM was written, Rhea Lydia Graham was remembered as a leader who had served the USBM with distinction and a high degree of dignity.

USBM Locations

At the time of its closure, the USBM had facilities in 13 locations around the country. In Washington, DC, the USBM's headquarters provided policy direction and administration support for program operations. There were nine Research

Centers, located in Albany, OR; Denver, CO; Minneapolis, MN; Pittsburgh, PA; Reno, NV; Rolla, MO; Salt Lake City, UT; Spokane, WA, and Tuscaloosa, AL. The USBM also had three Field Operations Centers, in Alaska (with offices in Anchorage and Juneau); Spokane, WA, and Denver, CO. In addition, there was a Minerals Availability Field Office in Denver, CO, and a Helium Operations facility in Amarillo, TX.

Major Accomplishments, 1910-89

The USBM made many contributions to the mining and mineral industries in its 85 years. One of the earliest and most significant accomplishments was the reduction in mine fatalities. *(See figure 3.)* Many more were to follow.

In 1911, the USBM's first metallurgical study found a way to remove sulfur from smelter fumes that were killing trees in public forests. In the 1920's, USBM smoke abatement studies helped Salt Lake City combat air pollution caused by its coal-burning furnaces.

In 1912, the USBM developed a low-cost way to extract radium needed for cancer treatment from domestic ores. By 1915, it had provided the technological jumpstart for mining domestic molybdenum, a key element for steel production.

Work on breathing devices provided new protection for rescue workers who had to enter mines to look for survivors or recover the dead. During World War I, the USBM used its expertise in this area to develop gas masks to shield American soldiers from poisonous gases.

In the 1920's, experts on mine gases established ventilation requirements for the Holland Tunnel, which linked New York City and New Jersey. (*See figure 4.*) This was done by measuring the exhaust gases from cars driven around an underground oval track built in the USBM's Experimental Mine at Bruceton, PA. USBM research on the ignition of anesthetic gases virtually eliminated the risk of explosions in hospital operating rooms.

The USBM developed an electric brass furnace and improved brickmaking technology.

In the 1930's, the USBM provided technical and support assistance to the National Resources Board, established by Executive Order 6777, in the preparation of their reports on mineral and material issues.

The USBM helped establish a cost-competitive potash industry in the southwest. The World War II years saw successes with electrolytic chromium, cobalt, and manganese processing.

In the 1940's, the USBM was responsible for providing technical and policy support to various wartime and post-wartime efforts to ascertain the Nation's mineral resource position.

In the late 1940's and early 1950's, Dr. William Kroll a refugee from the Nazi war machine, worked for the USBM on technologies for handling reactive metals such as zirconium and titanium. Zirconium research was so successful that the U.S. Navy and Atomic Energy Commission asked the USBM to build a commercial-scale plant and produce the metal for use in nuclear reactors. *(See figure 5.)* USBM zirconium made possible the first atomic powered submarine, the *USS Nautilus*, and the beginnings of the nuclear Navy. The Kroll process remained in its original form or modifications thereof and was the principal method used at the time of publication for economically recovering titanium and zirconium metal from their ores.

USBM research resulted in techniques that were the basis of gold recovery for the U.S. gold mining industry at the time of publication. First, the USBM, in cooperation with others, developed a carbon adsorption/desorption process for extracting gold from pregnant cyanide solution and regeneration of the carbon. The method entailed the use of a hot sodium hydroxide-cyanide solution to strip the gold and silver values into a concentrated solution, and an electrolytic mass transfer cell to plate the precious metals onto steel wool. The sodium hydroxide-sodium cyanide electrolyte and steel wool cathode remained common to the electrowinning cells used in many commercial operations in the United States, as well as all over the world. Then, this treatment was combined with the dump-leaching technology that was used on low-grade copper ores. The resulting process permitted the treatment of very coarse, low-grade ores that would otherwise require prohibitively expensive grinding and agitation-leaching equipment. The modest capital cost for the heap-leach installations was only about 10% of the plant investment needed for conventional milling operations. (*See figure 6.)* The revival of the domestic gold industry in the 1980's was due, in part, to this technological development. The technique allowed new, nontraditional mining companies to enter a field from which they previously had been excluded. The process was selected by *Chemical Engineering* magazine as one of the top technical developments in the chemical process industries for the period October 1969 to April 1970.

For most of the first half of the 20th century, the USBM stood alone in the development of fundamental thermodynamic data as a key element in the evolution of a modern efficient industrial society. By 1950, the USBM's thermodynamic research group had produced, in just 24 years, between 50% and 70% of the basic thermodynamic data used to design and operate smelters and reaction vessels, and to develop new high technology metal alloys. The publication of these data took many forms, notably the USBM Bulletins, Volumes I-XII, "Contributions to the Data of Theoretical Metallurgy."

The USBM provided technical and policy support to the Paley Commission (The President's Material Policy Commission) that was established to study the materials problems of the United States and its relation to the free and friendly nations of the world.

In the mid-1950's, the USBM provided technical and policy support to the Second Hoover Commission in the development of its report evaluating the operation of the National Stockpile. In subsequent years, the USBM continued to provide technical and policy support on the operation of the National Critical Materials Stockpile.

The USBM devoted much attention to the problem of controlling mine roofs and was largely responsible for the adoption of roof-bolting in coal mines.

The USBM had a long record of contributions to the iron and steel industries, the Nation's industrial backbone. For example, 1960's blast furnace research attracted the cooperative support of 22 U.S. steel companies. Technology developed by the USBM as a result of this work was incorporated into modern blast furnace practice.

The Wilderness Act of 1964 added U.S. Forest Service (USFS) areas and acreage to the national wilderness system and designated that the USBM and USGS should conduct mineral surveys of wilderness lands on a planned and recurring basis. After 1964, subsequent legislation added significant USFS acreage to the wilderness system, and, in 1976, significant Bureau of Land Management (BLM) lands were designated wilderness with the same mineral survey requirements. In nearly 30 years of wilderness investigations, the USBM evaluated nearly 2,000 individual wilderness areas and produced about 1,500 technical mineral reports mainly for the USFS and BLM. In conducting field studies in remote, rugged areas with wilderness system access restrictions, the USBM had a good safety record until 1992. In one of the last wilderness system field investigations, and at the BLM's request for a field analysis of the Scotts Basin Wilderness Study Area, Deep Creek Mountains, UT, two USBM geologists, Brian Hannigan and Steve Tuftin, were killed by lightning.

In the late 1960's, the problem of junked automobiles received a great deal of public attention. Part of the problem was the open burning of the car bodies before they could be sold as steel scrap. The USBM designed an incinerator that would burn the cars without smoke emissions. Based on this design, 29 commercial incinerators were built and operated around the country, burning a significant portion of the 10 million autos scrapped each year. The smokeless incinerator served as an economical interim solution to a nagging national problem.

In 1972, in response to Public Law 91-631, the USBM prepared for the Secretary of the Interior the *First Annual Report of the Secretary of the Interior under the Mining and Minerals Policy Act of 1970.* In subsequent years, the USBM staffed similar Secretary Annual Reports on Mining and Mineral Issues.

Drainage from mines was one of the most significant environmental problems facing land managers. Heavy metals and the acidic nature of the drainage threatened aquatic life and drinking water sources. The USBM developed a number of methods for treating this problem. *(See figure 7.)*

The toll that mining could take on the land became apparent by midcentury. USBM studies of abandoned mine problems dated back to the 1950's when the legacy of coal mining and the well-being of communities began to collide. Subsidence had damaged homes and other structures built over old mines. *(See figure 8.)* USBM scientists injected wastes such as fly ash into underground workings to stabilize the earth and buildings above, in addition to developing state-of-the-art production technology and structural protection criteria.

Fires at abandoned mines were another focus for the USBM's early remediation research. Control efforts included trenching to isolate the burning material, and injection of a cryogenic slurry to extinguish the material.

Reclamation became a regulatory concern when the Office of Surface Mine Reclamation and Enforcement was established in 1977. USBM research supported Federal and State agencies tasked with restoring mined lands.

An economical way to recover iron ore from nonmagnetic taconite substantially increased the Nation's iron ore production capacity. *(See figure 9.)* Using selective flocculation combined with flotation, more than 90 million metric tons of iron ore pellets have been produced as a result of the USBM's research activities.

The first systematic USBM studies of Indian lands were a series of mineral reconnaissance studies and reports in the 1960's on all 22 Indian reservations in the Missouri River Basin. These reports were intended to identify all the available mineral resource information for each reservation in an effort to enhance Indian employment and income through mineral development. In 1974, the USBM, USGS, and the Bureau of Indian Affairs agreed to support a nationwide series of Indian lands mineral studies that would support the "self-determination" goals of tribal organizations and the responsibilities of the Secretary of the Interior. By 1991, the USBM had completed Phase I studies (literature searches) on 270 Indian reservations, and Phase II and Phase III studies (detailed geological investigations, including drilling, and bulk metallurgical sampling and testing) on more than 50 reservations. In addition, the USBM's Minerals Availability Field Office, Denver, CO, consulted with several tribal investigations for the successful negotiation of lease agreements to produce energy minerals.

The USBM began evaluating domestic clay and shale resources in 1938. Data from the research demonstrated that shales and clays could be used to make lightweight aggregate suitable for structural concrete applications where weight reduction was an important consideration. This resulted in the establishment of an industry to produce lightweight aggregate for concrete. In related research begun in 1979, the USBM, working with the Federal Highway Administration, pioneered the use of synthetic ceramic aggregates such as waste slate and copper mill tailings to improve wear and skid resistance on paved road surfaces.

The USBM conducted extensive research to solve some of the severe materials corrosion problems inhibiting the development of liquid-dominated geothermal resources for energy and mineral values. This research provided an extensive data base for the selection of materials for constructing geothermal plants. USBM research scientists were frequently contacted by major geothermal facilities contractors for specific materials recommendations.

In 1980, the Alaska National Interest Lands Conservation Act (ANILCA) was passed creating large Federal conservation units in Alaska and Section 1010 required mineral assessments of all conservation units. To respond to this mandate, the USBM, which had been working in Alaska since the USBM was created in 1910, began a series of studies of mining districts that were prioritized according to land management agency need, known mineral potential, and degree of transportation infrastructure present. Mining districts completed included Valdez Creek, Juneau, Ketchikan, and Colville. Over the years, the USBM's work in Alaska resulted in recognition of important mineral potential in previously unrecognized areas that resulted in industry discoveries, Native and State land selection decisions, and land-use decisions. Most notable among these were the discoveries of massive sulfide mineralization that led to the discovery the Red Dog Mine, *(see figure 10)* a world class lead-zinc mine. Other significant accomplishments included mineral alternative support for the Tongass National Forest land-use plan. Because of the significance of the remaining ANILCA-mandated work to be accomplished, the Alaska Field Operations

Center of the USBM was transferred to BLM to continue the ANILCA work.

With the increasing concern about import dependency and the potential resource war, the USBM played an important role in assisting the various government agencies and commissions examining this issue. The USBM policy office developed a number of reports discussing this issue, including the 1985 report requested by the Chairman of the Transportation, Aviation, and Materials Subcommittee of the U.S. House of Representatives concerning the issue of South Africa and the Nation's dependency on critical materials from South Africa.

At the time of the USBM's closure there were two program directorates: Information and Analysis and Research.

Principal Programs and Accomplishments, 1990-95

Information and Analysis

The Information and Analysis Directorate's mission was to provide timely, unbiased information to support policymaking affecting the minerals and materials position of the Nation and to contribute to informed decisions about major national issues affected by resultant policies. The five directorate programs collected data on the production and consumption of more than 100 mineral commodities in the United States and from 190 foreign countries. They also assessed the worldwide availability of minerals, and analyzed the impact that Government policies, economic conditions, and Federal land-use decisions had on the Nation's ability to provide for itself a sustainable supply of minerals. To support these responsibilities, the Directorate maintained a unique body of expertise that included commodity, materials, and foreign country specialists, engineers, geologists and other scientists, policy analysts, economists, and other professionals with special skills. These professionals were supported by two large-scale state-of-the-art information systems, the Automated Minerals Information Systems (AMIS) and the Minerals Availability System/Mineral Industry Location System (MAS/MILS). The results of this work were disseminated worldwide through a highly regarded series of statistical and analytical publications.

Commodities and Materials

Program Description, 1990-95

The commodities and materials program provided information and analysis on mineral/material flows and was one of the key supports for other USBM analysis and research activities. The program addressed fundamental trends in materials use in the United States and other industrialized nations. Program activities also developed overall data on materials flows by industrial sector nationwide and provided an analytic and technical framework to assess why and when substitution was likely to occur; evaluate the long-term implications of increasing reliance on nonrenewable resources; develop information on material recapture, waste reduction potential, and ultimate discards to the environment; and develop needed information on emerging high technology advanced materials.

Commodity specialists in the program provided reports and consultative services on virtually every technical/economic activity involving minerals from exploration and mining through recycling and disposal. The specialists assessed data on more than 100 raw-processed minerals and disseminated information to Government, industry, and academia through consultative services, special reports, and more than 400 recurring publications. This work was done to identify important new minerals and materials trends and to provide Congress and the Executive Branch with options that responded to national issues associated with those trends. This program was transferred to the USGS.

Accomplishments, 1990-95

The commodities and materials program produced the minerals and materials volume of the USBM's world-renowned *Minerals Yearbook*. (*See figure 11.*) Specialists in the program wrote approximately 80 annual commodity reports which comprised Volume I. These reports provided the most comprehensive information available anywhere on U.S. mineral industries.

The program produced monthly, quarterly, and annual *Mineral Industry Surveys* (MIS) for mineral commodities. About 400 of these reports were produced each year to provide the latest Government information available to spot trends affecting prices, employment, and supplies and included information on new developments in production and consumption. These free publications were distributed to more than 50,000 subscribers on a monthly, quarterly, and annual basis. In addition, the MIS were distributed electronically via the USBM's FaxBack system, which delivered the reports 24 hours a day, 7 days a week.

Commodity and materials specialists provided technical advice and support to innumerable policy-setting initiatives in both Government and industry. By 1996 when the USBM closed, the specialists were responding to more than 2,000 customer requests every month. For example, commodity specialists provided data and analysis used as the foundation for resolving international trade disputes, assessing import reliance, *(see figure 12)* combating terrorism, and managing the National Defense Stockpile. In addition, materials specialists working with the Council of Great Lakes Governors developed an integrated assessment of material flows in the Great Lakes region and identified appropriate market opportunities where the buying power of State Governments in the region can be used to promote recycling markets.

Each January, the program published *Mineral Commodity Summaries* and its predecessor *Commodity Data Summaries* covering nearly 100 minerals and materials. This report provided the first review available on industry events, trends, and issues of the prior year.

The program published three innovative volumes of *The New Materials Society*, which presented a comprehensive overview of new materials issues, trends, and impacts in the United States. These were used in industry and Government, as well as textbooks at some universities.

Material balance studies were developed for selected mineral and metal commodities covered by the program. These studies detailed the full life cycle of the commodities from extraction through manufacturing, use, recycling, and ultimate disposal. The studies were designed for use by mineral industries and the environmental community to identify potential targets for source reduction, decreasing process inefficiencies, and eliminating dissipative uses.

Material specialists developed indicators of material use trends and patterns as part of an ongoing Federal effort to define resources stewardship. This work assisted the Interagency Working Group on Sustainable Development Indicators, the Interior Department Task Force on Natural Resource and Environmental Indicators, the Interagency Council on Environmental Technology, and the goals and indicators working group of the President's Council on Sustainable Development.

The publications and services of the commodities and materials program were expected to continue at the USGS.

International Mineral Studies

Program Description

This program was designed to assist U.S. industry and Government in meeting strategic material and global competitive objectives. The program was structured to assess and respond to the dynamics and complexities of a global economy and its impact on the competitiveness of the U.S. minerals industry.

The international minerals studies program focused on worldwide issues of resource availability, production, consumption, trade, economics, technology, and the environment as related to minerals and materials industries. Special emphasis was placed on issues affecting U.S. and world mineral markets.

This work, carried out by the USBM's country specialists, monitored the mineral industries of some 175 countries, representing a multitrillion dollar global mineral economy and more than $500 billion in global mineral trade flows. These studies provided U.S. decisionmakers with the fundamental information on the industrial capacity, production plan, trade practices, labor and energy constraints, level of technology, mineral and foreign investment policies, and the environmental practices of countries that supply essential minerals to the United States, as well as those that compete with the United States in global mineral markets. This worldwide data gathering effort was the foundation of the USBM's international program and laid the groundwork for in-depth analyses that were essential for effective decisionmaking.

The USBM maintained an ongoing program to assess major issues affecting the competitive position of the domestic minerals and materials industry in world markets, the international financing of foreign minerals projects, and materials industry, including the implications of bilateral and multilateral trade agreements. Those assessments provided mineral-related technical and economic advice to the U.S. Trade Representative (USTR), other Government agencies, and international development finance organizations to help formulate and implement U.S. trade policy. Part of this program was transferred to the USGS in January 1996.

Accomplishments, 1990-95

The major, worldwide recognized product of this program was the *Minerals Yearbook-International Review*, an annual in-depth analysis of the global minerals industry in 180 countries. This review, which was to continue to be published by the USGS, provided comprehensive reports and analysis of worldwide mineral industry developments, the status of mining and foreign investment laws in each country, mineral locality maps, industry ownership and capacity tables and an industry outlook section. The International *Minerals Yearbook* was widely used as a standard reference on the international minerals industry by Government policymakers, the mining industry, related equipment manufacturers and service companies, and by the international financial community. To respond to customer surveys requesting more timely data, since 1995, individual country reviews were made available to the public as soon as prepared through an on-demand FaxBack system.

USBM country specialists also prepared a number of more in-depth studies on selected countries in the *Minerals Perspectives* and *Minerals Issues* series of the USBM. Recent *Minerals Perspectives* included detailed studies on the *Mineral Economy of Mexico* (1992), highlighting the importance of minerals to the Mexican economy as the country joined the North American Free Trade Agreement (NAFTA); on the *Mineral Industries of Guinea* (1990) highlighting the world's largest resources of bauxite along with their additional diamond, gold, and iron ore production potential; and *A Regional Assessment of Selected Mineral Commodities in Subequatorial Africa* (1991), published jointly with the British Geological Survey and the Geological Survey of South Africa. This latter study, published under the umbrella of a six-nation International Studies in Mineral Issues working group, assessed the mineral resource potential of 27 commodities in 19 central and southern African countries and highlighted associated infrastructure issues in the region.

The *Minerals Issues Series* provided a forum for the International Division's primary language research into selected strategic mineral sectors of China and the former Soviet Union. Recent publications have included the "Iron and Steel Industry of China" (1990) and "The Light Metals Industries of China" (1993) covering the aluminum, magnesium, and titanium industries.

The USBM's country specialists served on an on-going basis as technical advisors to USTR and the Departments of Commerce, State, Treasury, and Defense providing input to a wide range of mineral related policy issues, from the sanctioning of strategic minerals from South Africa under the Comprehensive Anti-Apartheid Act, to Cuban nickel sanctions; on a number of commodity dumping issues, such as with tungsten imports to the United States from China; and on mining-related environmental issues associated with Chile's proposed accession to NAFTA and related to the United States-Canada debates over the development of the Windy Craggy copper deposit in British Columbia. The State Department also drew on the USBM country specialist expertise to provide briefings to newly assigned Ambassadors and other diplomats on mineral industry issues in their assigned countries.

For the Interagency Working Group on Multilateral Aid, the USBM coordinated the evaluation of proposed mineral project loans by international financial institutions. In an average year, at least 2 dozen evaluations of proposed projects were completed. These assessment activities contributed to the World Bank's decision to pursue a more conservative lending policy. Proposed Export-Import Bank loans and guarantees for mineral projects also were examined by USBM staff who served as the Department of the Interior representatives at meetings of the National Advisory Council on International

Monetary and Financial Policies.

The USBM represented the Department on the Section 409(b) Committee chaired by the USTR. The Committee, established in response to the United States-Canadian Free Trade Agreement, identified U.S. industries that would lose domestic markets to subsidized Canadian exports. The USBM analyzed a petition by the Nonferrous Metals Producers Committee that sought identification of the copper, lead, and zinc industries as industries that would be adversely affected by competition from Canadian producers. Because of this analysis, all three industries gained access to USTR information on Government subsidies that support their Canadian competitors.

At the request of the Department of State, the USBM conducted an analysis to estimate the direct economic impacts of a U.S. import embargo on strategic and critical minerals produced in South Africa. This analysis was used to assist the Administration and Congress in determining the economic impacts of a successful U.S. embargo of South African strategic and critical materials. The estimates were used in the congressional debate over amendments to the Comprehensive Anti-Apartheid Act of 1986. At the request of the Chairman of the House Energy and Commerce Committee, the USBM conducted a follow-on study to estimate the impact that a successful U.S. embargo on South African platinum-group metals would have on employment and the gross national product. In addition, an assessment of materials that experienced a significant growth in demand and reduced domestic availability was completed and distributed to Congress, Federal agencies, and the public. This type of assessment provided an early-warning system for situations in which the disruption of imported materials supplies could adversely affect the Nation.

The USBM represented the Department on committees dealing with the Environmental Side Agreements of NAFTA, and development of policy positions for Latin American mining considerations and implementation language for the Basel Convention and for the United Nations Law of the Sea Treaty and the supplemental Seabed Mining Agreement. The domestic mineral resource effects of the recent liberalization of the Latin American mining laws and investment climates were evaluated.

International trade and environment agreements were reviewed to identify and evaluate impacts on the U.S. minerals industries competitiveness. The USBM reviewed the Montreal Protocol, the Basel Convention, the London Dumping Convention, the Protocol on Environmental Protection to the Antarctic Treaty, and the United Nations Conference on Environment and Development accords. Special attention was given to proposals that could adversely affect trade flows of recyclable mineral wastes. The USBM worked with the USTR, and with the interagency Trade and Environment Working Group to develop U.S. policy with respect to minerals trade and related environmental impacts. The U.S. positions were used for these agreements at meetings of the General Agreement on Tariffs and Trade and the Organization for Economic Cooperation and Development. The USBM also worked with USTR, the Environmental Protection Agency (EPA), and the U.S. State Department to develop international environmental policies.

Land and Mineral Resources

Program Description, 1990-95

The land and mineral resources program was organized into three components: Mineral Land Assessments, Minerals Availability, and Minerals Environmental Studies.

The mineral land assessment program component employed field geologic and engineering methods to estimate the future mineral supply potential of public lands managed by, mainly, the USFS and the BLM. These assessments helped identify and evaluate trade-offs between possible minerals development and protection of environmental values such as wilderness areas, endangered species habitats, or watersheds. Geographic Information System (GIS) and economic analysis techniques were used extensively in these studies.

The minerals availability program component included sensitivity analyses of the impacts of technologies, regulations and policy alternatives on the production costs and economic viability of mines and mineral deposits. This activity was supported by mining, metallurgical and cost-estimating engineers, economists, mineral analysts, and the Minerals Availability System (MAS). A data base was developed on mineral reserves, production costs, and technologies for more than 3,000 major world mines, mineral processing plants, and mineral deposits. Capital and operating costs were estimated to determine the competitiveness of each mine. Availability studies were published periodically for 3 dozen commodities essential to the National economy or security.

The mineral environmental studies program component utilized USBM expertise to help resolve the growing Government liability for environmental and safety hazards at inactive and abandoned mines on public lands. The MAS/MILS data base, *(see figure 13)* on more than 200,000 U.S. mineral locations, was used to quantify and prioritize inactive and abandoned land sites for Federal land managers. Field geologists and engineers evaluated the content and distribution of heavy metals and toxic elements in mineral wastes piles in order to characterize environmental risks and to identify remediation strategies.

Accomplishments, 1990-95

The late 1980's and early 1990's saw Federal land managers faced with more complex land use decisions involving very large acreages, frequently in excess of 5 to 10 million acres. The USBM continued a high level of decision support through land assessments addressing economic and environmental protection options. Major studies were conducted in the mineral-rich West Mojave Desert in support of a special coordinated land management plan. To protect the desert tortoise, Mojave ground squirrel, and other endangered species USBM analysts supported development of the Environmental Impact Statement planning alternatives relative to species protection and economic development alternatives.

Multiyear mineral assessments were conducted on BLM land in Nevada, in the Winnemucca planning unit and for the Humboldt River Basin. The USBM addressed the mineral resources, modeled the economics of mineral development possibilities, and inventoried inactive and abandoned mine land sites. *(See figure 14.)*

The USGS assessments in the Salmon and Beaverhead National Forests supported a major ecosystem management initiative in the Columbia River Basin of Idaho, Montana, Oregon, and Washington. This study helped to develop a management and land-use policy framework for the Northwest with its principal objectives to rehabilitate salmon habitat, preserve old growth forest, and generally provide for environmentally compatible economic development.

The decline of communism provided the opportunity to expand the coverage of minerals availability studies, making them truly global. Twelve hundred mining properties in the former Soviet Union and eastern Europe and 600 in China were added to the MAS/MILS data base. A CD-ROM version of MAS/MILS made this comprehensive collection of geographically referenced data on more than 220,000 mineral properties easily accessible to the public.

Twelve minerals availability studies were published to reflect significant changes in mining and processing technologies as well as changing market conditions. For example, a gold appraisal was driven by the soaring 1980-90's production in the United States and other parts of the world and by attendant environmental conflicts and mineral policy questions. It provided critical data for a major study that estimated Government revenues and employment effects from proposed revisions to the U.S. Mining Law.

Innovative, USBM-developed analytical methods were used to fill gaps in Government information about U.S. coal reserves and international coal trade. Studies of 14 map quadrangles in Central Appalachia showed that recoverable coal resources were much lower than had been previously estimated. In the international arena, eight bilateral cost comparisons studies were completed comparing U.S. costs with comparable producers in Australia, Canada, Colombia, Indonesia, Poland, Russia, South Africa, and Venezuela. These competitiveness studies identified principal differences in costs among the world's competing export coal producers.

To ensure that IAM inventory surveys were conducted cost-effectively and consistently by Federal land managers, the USBM developed the step-by-step *Abandoned Mine Land Inventory and Hazards Evaluation Manual*. Major IAM inventories were conducted for the USFS in Washington State and of the Cornonado and San Bernardino National Forests in Arizona and California, respectively. Additional studies were done in Alaska (Chugach and Tongass National Forests), and in Idaho, Montana, Nevada, Utah, and Wyoming. Working with a Department of Interior task force, the USBM took the lead in developing a prioritizing mechanism for IAM sites.

In cooperation with the National Park Service (NPS), the USFS, and several State governments, the USBM characterized environmental problems and risks associated with past mining operations. Studies included the historic Kennicott Mine in the St. Wrangell-St. Elias National Park and Preserve in Alaska, mercury mines in the Big Bend National Park, Texas, and gold mines near Lake Mead National Recreation Area.

Regulatory Impact Analysis

Program Description

As the Nation became more aware of the environmental impacts of industrial developments, the USBM incorporated Regulatory Impact Analyses into its policy analysis efforts. Its goals were to identify and assess a growing body of regulatory and legislative issues and their impacts on the development and utilization of the Nation's mineral and material resources. Working in close cooperation with legislative bodies, regulatory agencies at both the Federal and State levels, public interest groups, and the minerals industry, the program focused on the analysis of the most pressing environmental problems. A major objective of these efforts was to provide policy officials with the information needed by them to make regulatory decisions based on sound science that allowed cost effective risk management solutions to be identified.

Analyses were conducted on legislative and regulatory issues such as the Endangered Species Act, Clean Water Act, Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response and Clean-Up Liability Act (CERCLA), as well as international agreements and regulatory proposals focusing on environmental and mineral trade issues.

Accomplishments, 1990-95

A study of pollution prevention and the minerals industry reviewed the evolution of the Nation's pollution prevention policy and its possible impacts on the minerals industry.

Methods were developed to measure mineral potential and the associated opportunity costs from mineral production for use in making decisions with regard to endangered species protection and recovery plans. It also developed a method for conducting analyses in response to regulatory issues related to mining and mineral processing wastes.

The USBM provided assistance to EPA in the development of proposed mine waste regulations for State implementation. Economic and technical evaluations were conducted of RCRA reauthorization impacts on minerals supply and uses. The USBM estimated the direct and indirect contributions of mining to regional and State economies, focusing on projected changes in employment, income, and tax revenues in selected States and counties resulting from mining activities.

The USBM examined the impact on the aluminum industry of increased electrical rates resulting from possible changes in the Clean Air Act. Studies estimating the costs of acid rain legislation for the energy-intensive silicon industry were also completed.

A study of risk assessment of inorganic contamination of groundwater from copper dump-leaching operations determined the risk-benefit ratio for various leach operation designs or regulatory options.

The USBM also helped EPA define specific classes of stainless steel and brass metallic scrap that should be exempt from EPA's Toxic Release Inventory reporting requirements.

Statistics and Information Services

Program Description

The USBM minerals information program was known worldwide as an authoritative source for comprehensive and accurate statistics on minerals production, consumption, and trade. Statistical data prepared by the Division of Statistics and Information Services (DSIS) helped

Members of Congress and other Federal agencies make decisions about land use, regulations, trade policy, defense preparedness, and other issues. In addition, thousands of individuals and organizations, such as mining industry executives and market analysts, depended on the USBM for information about minerals.

DSIS was responsible for collecting and publishing many of the official mining and mineral statistics of the United States, along with the latest available international minerals statistics. These statistics and their interpretations were presented in a variety of publications, including the flagship *Minerals Yearbook,* which documented world production, consumption, and trade of mineral commodities. *Mineral Commodity Summaries* presented an annual summary of minerals information. Bound editions of these publications and CD-ROMS were sold by the Government Printing Office.

Within USBM, DSIS not only was responsible for the preparation of the statistical portion of periodic and special statistical publications, but also for developing, testing, and implementing new and improved methods for collecting data, and for providing capability in computation and communication state-of-the-art technology, technical data base administration, and electronic dissemination.

In addition, DSIS maintained the AMIS. AMIS was an integrated system with information on mineral production, capacity, consumption, industrial stocks, strategic stockpiles, imports, exports, reserves, and recycled materials. AMIS, the backbone of the USBM's survey processing effort, had been undergoing a major four-phase upgrade project. Data collected from domestic minerals production and consumption operations were used to generate statistical publications and support analytical activities.

Domestic minerals data were monitored through a voluntary system of commodity canvasses. This unique partnership with mineral producers and consumers not only enabled the production of high-quality statistics, but also represented a substantial contribution in-kind to the Government by industry, estimated at $1.9 million annually. More than 18,000 producer and consumer establishments took part in the program each year by completing more than 40,000 survey forms. In addition, the USBM had memoranda of understanding to share collected data with 47 of the 50 States, thus saving them an estimated $5 million annually. This program was transferred to the USGS.

Accomplishments, 1990-95

Among the Division's other noteworthy accomplishments in recent years was *Metal Industry Indicators,* which reported on coincident and leading indices for the primary metals industry, as well as the copper, steel, and aluminum industries. Another publication was the *Statistical Compendium,* first as a book and later as a CD-ROM, providing official historical statistics of the United States for selected minerals in formats more readily accessible to researchers and analysts. DSIS also produced other CD-ROM's presenting a large variety of previously printed USBM publications. In addition, the Division maintained MINES-DATA, an online electronic bulletin board system, and was responsible for the Minerals Archival and Retrieval System, a micrographic system installed to centralize survey processing procedures and to allow rapid retrieval of historical and current minerals information. DSIS also initiated a human resources study that resulted in upgrading of statistical assistant positions through improved career ladders, hence reducing attrition and increasing productivity.

Research

The USBM research program developed the scientific basis for technology to help meet the Nation's mineral and material needs and mitigate associated economic, human, and environmental costs. The program, with headquarters in Washington, DC, sought improvements for almost every aspect of the materials production cycle, from removing mineral from the earth to enhancing the performance of materials, then beyond to pursue waste management technologies for the recovery of spent mineral values and resource conservation. The health and safety of the workers in the Nation's mines and mineral processing plants, and the environmental impact of mining and mineral processing, were major USBM concerns. The strategic objectives of the program were:

> To provide the scientific basis for the necessary extraction, worker health and safety, and waste management technologies to meet the Nation's materials requirements.
>
> To provide environmentally compatible materials and processes that conserve our natural resources, and that enhance U.S. product innovation, industrial productivity, and economic growth.
>
> To provide cost-effective technology for the permanent cleanup of past environmental problems associated with mineral production and use, especially problems on those lands over which the Department of the Interior has stewardship responsibilities.

The research program was structured into three major research areas: Environmental Technology (ET); Health, Safety and Mining Technology (HSMT); and Minerals and Materials Science (MMS).

Environmental Technology

Program Description

The ET program conducted research to provide the science base for technologies to reduce the volume and toxicity of liquid and solid wastes generated through minerals-related activities; remedy hazardous waste sites contaminated with heavy metals throughout the country, especially those on Federal lands; and mitigate the environmental effects of coal and hard-rock mining on active and abandoned mine lands. The first ET research area, Control of Mine Drainage and Liquid Wastes, had as its goal the prevention, mitigation, and control of contamination of the Nation's waters from the results of mining and mineral processing. The second research area, Solid Waste Management and Subsidence, had as its goal the development of cost effective technology for the disposal of mining and mineral processing wastes from then current operations and the remediation of environmental damage resulting from past mining and waste disposal activities. The third research area was Hazardous Waste Treatment Technology, the goal of which was to develop more efficient and cost-effective technology for the remediation of hazardous waste sites and to find better methods to characterize these sites. The fourth research area was Abandoned Mined Land Reclamation Research. Its goal was to develop more efficient and cost-effective technology for the remediation of hazardous waste sites and to find better methods to characterize these sites. The last research area in the ET program was the National Mine Land Reclamation Center. Its goal was to develop more efficient and cost-effective technology for the remediation of hazardous waste sites and to find better methods to characterize these sites.

Accomplishments, 1990-95

Vitrification studies garnered support from more than 35 public and private sector partners. Tests showed that municipal incinerator ash can be turned into a usable glass product. The DOE believed the process is applicable to treating low level radioactive wastes.

Research on revegetation, slope stabilization, and other reclamation technologies provided ways to turn old strip mines into usable land.

The agency also applied its metallurgical expertise to a variety of other environmental problems. Scientists developed an electrolytic technique for cleaning up battery breaker Superfund sites and showed that physical separation technologies can remove lead from soil at military firing ranges.

Environmental applications of flotation included treating lead mill wastes in Missouri and removing organic contaminants from Great Lakes and Chicago River sediments.

The USBM developed dewatering technology for Florida phosphate slimes, Alaska placer mines, and crushed stone quarries. The technology yielded a marketable product from the waste materials. Work with biotechnology included identifying bacteria that remove arsenic, selenium, and cyanide and using peat moss beads, an R&D 100 Award winner in 1990, to clean up metal-contaminated water.

Abandoned mine shafts were a hazard to people and animals. The USBM developed low-cost ways to plug old mine shafts. USBM guidance helped the NPS and other land-managing agencies evaluate mine openings and select the best way to make them safe.

The USBM supported other Department of the Interior agencies by technical assistance studies that addressed issues at the Midnite Mine in Washington State. Studies included determination of treatment options for the contaminated water at the site that would remove contaminants prior to sludge production, the flow of groundwater through bedrock and potential for offsite migration of contaminated water, acid generation potential of large spoil piles, and radiation studies for purposes of reclamation.

Health, Safety and Mining Technology

Program Description

This program pursued fundamental scientific and engineering research to provide new technology to protect the Nation's miners, who were employed in one of the most hazardous of all occupations. It focused on solutions to the health and safety hazards that confronted miners and other workers in the mineral sector of the economy, including exposure to dust, falls of roof, proximity to large equipment in confined space, and the potential for fires and explosions. This program also concentrated on long-range activities to devise new mining concepts that would safeguard miners with mechanisms that rapidly warned of, or suppressed, hazards in advance of mining, thus enhancing productivity. This program was transferred to the DOE.

The first research area was Occupational Health, which had as it goal the development of technology that would provide for a healthy environment for the workers in the Nation's mines and mineral processing plants. The second research area, Ground Control, had as its goal the development of technology to forecast impending catastrophic failure, maintain structurally sound and stable mine openings, and reduce injuries and fatalities caused by ground failure. The third research area was Human Factors. Its goal was to provide a safer work environment that incorporated the needs and limitations of the human worker to optimize performance in the total mining system. Mine Safety Systems, the fourth research area, had as its goal the development of new technology and the application of existing technologies pursued to remove or mitigate safety hazard in mines. The fifth research area, Mine Disaster Prevention, had as its goal the avoidance or elimination of fires and explosions through early detection, containment, and suppression; the prediction, measurement, and removal of dangerous methane accumulations; the development of protective breathing equipment and efficient escape tactics; and the safe and optimal use of explosives. Advanced Mining Systems was the last research area in this program. Its goal was to ensure that mining technology required for the future would provide a healthy and safe environment for the worker.

Accomplishments, 1990-95

The USBM received 22 R&D 100 Awards for major accomplishments in health and safety research. These awards were presented annually by *Research and Development* magazine for the 100 most technologically significant new products. Overall, the USBM received 33 R&D 100 Awards, and ranked 13th in the world in the number of these prestigious awards. The USBM also was awarded more than 500 patents.

Cooperative work with industry on in-situ copper mining promised to open up new sources of copper and provide a mining technology that leaves the surface of the land virtually untouched.

Minerals and Materials Science

Program Description

Minerals and materials science research addressed technology needs in the conservation and extraction of mineral resources. The research accelerated the realization of National priorities such as natural resource and environmental preservation, especially in economic sectors made up of small, independent, and widely scattered operations.

Conservation research provided environmentally sound raw materials processing and recycling technologies, which directly maximized the recovery of valuable minerals from each ton of ore mined and reduced loss of materials as the result of disposal and degradation (e.g., wear and corrosion), thereby decreasing land disturbance.

Extraction and separation research focused on pollution prevention and control. Research emphasized innovative technology leading to new materials, processes, and/or facilities to prevent environmental problems. This focus contrasted with research conducted by the ET subactivity, which developed technology to remediate environmental degradation from past mining and raw materials production. However, the cutting edge of the USBM's environmental remediation technology was based on its 85 years of experience in extractive science.

The goal of the minerals research program was to ensure that the Nation has an adequate technology base to address the long-term problems of materials supply into the 21st century. This base was essential if a domestic raw materials industry were to compete in a global economy while addressing environmental compatibility, land disturbance minimization, and resource conservation.

The materials part of the minerals and materials science program was transferred to the DOE. While it was part of the USBM, its goal was to protect the environment and infrastructure, to conserve domestic resources and reduce energy requirements through increased service life, and to provide new technology for the development of value-added engineered materials. As such, it was in support of the Department of the Interior's priorities of environmental protection and resource conservation.

Accomplishments, 1990-95

USBM research on heap leaching precious metals and improved gold recovery techniques set off a new "gold rush" that allowed mining companies to recover gold from low-grade ores. It was the basis of the U.S. gold industry.

The agency had a hand in fine-tuning almost every common mineral processing technology. Contributions to flotation, for example, date back to the first flotation of nonsulfide ores in the 1930's and included more recent work on column flotation, electrochemical parameters, and automated controls.

The USBM was a leader in developing recycling technology. Examples included the recovery of platinum-group metals from automobile catalysts and the separation of valuable metals from municipal refuse. These technologies became the basis for current commercial practice.

USBM contributions in melting and casting included induction slag melting of reactive metals, cast-in-place hard facing, mold materials for reactive metals, and evaporative pattern casting of steel.

What to do with what the Nation throws away was another major problem the USBM tackled. The agency developed a smokeless incinerator for use in getting rid of the millions of automobiles Americans discarded. When shredding junk cars became the state-of-the-art, the USBM followed up with techniques for separating and recovering nonferrous metals from automotive scrap.

USBM scientists found ways to recycle metals, plastics, and paper from municipal wastes. They came up with clean technology for recycling lead-acid batteries and ways to recover silver from photographic solutions. They developed a spark identification technique for detecting valuable metals in mixed scrap and recycling technologies for electronic equipment. Recent recycling work recovered graphite from kish, (ironmaking waste containing graphite) which received an R&D 100 Award in 1992, and platinum from used automobile catalytic converters.

The Closure of the USBM

During the summer of 1995, as the Congressional budget process for fiscal year 1996 was proceeding, the U.S. Senate and House of Representatives held two distinctly different views of the destiny of the USBM. The Senate Interior Subcommittee supported the Administration's proposal for funding at $132 million. The House of Representatives Appropriation Subcommittee recommended the abolishment of the USBM. In September, the Conference Committee composed of members from both houses of Congress recommended the closure of the USBM with the following program transfers to other agencies:

> The Health and Safety Research Program at the Pittsburgh, PA, and Spokane, WA, Research Centers, and Materials Research Program at the Albany, OR, Research Center would be transferred to the DOE.
>
> The Land and Mineral Resources Program studies at the field offices in Anchorage and Juneau, AK, would be transferred to the BLM.
>
> The minerals information components of the Information and Analysis Program in Washington, DC, and Denver, CO, would be transferred to the USGS.

The end of the USBM came suddenly and surprisingly. Furthermore, closure of this statutory agency was to take place in an unprecedented 90 days. The Director commented on the impacts of the USBM closure to The Second International Conference on the Health of Miners on November 11, 1995.

> "Investment in R&D increases growth and productivity, leading to a higher standard of living. Numerous studies demonstrate that 'investments in R&D yield high returns to investors and even higher returns to society.' While private industry funds the majority of R&D, there is a serious underinvestment in some fields, such as miner health. In these areas, the returns to society may be large, but the returns to the individual or private company may not be sufficient to encourage investment. I do not need to remind the industry nor the employees of the USBM what the failure to recognize this concept has cost us. I have just returned from visiting in the last 4 weeks the 12 locations where USBM employees work from Alabama to Alaska. Of these 1,700 employees, 1,200 will no longer have Federal employment on January 22, 1996 [subsequently extended to February 3, 1996]. Many are Ph.D. scientists and engineers who came to the Federal workforce because they knew that the return to society was large for what they do, even though the private sector could not afford the costs of the investment. As we know, this work is not a subsidy to industry. Pollution prevention and control and environmental remediation research benefit nonmining users of land resources significantly. And spillover effects into other parts of society keep growing. We see our values clouded in a type of sadness that I would not wish on anyone."

A Tribute to the People of the USBM

Since its founding in 1910, the strength of the USBM has come from the diverse talents and dedication of its people. Speaking at the Commemoration of the USBM on December 13, 1995, the Director honored the USBM's employees.

> "There is no easy way to speak of the hurt that comes from a decision that ends one's opportunities in public service. There is an abundance of riches, however, to celebrate from the accomplishments and innovations of the USBM. ... We in the USBM have always fought an uphill battle of understanding. The role that mining and minerals plays in our society has frequently been framed in extremes: extraction versus preservation. Yet, the common ground is, everyday we all live off mining and minerals. Therefore, it was imperative that the USBM staff render unbiased and professional research and analysis for use by our Nation's leaders. And that you have done, for 85 years. ... My fellow colleagues, you have used your skills well, and have served this Nation faithfully."

The introductory chapter of the last USBM *Minerals Yearbook* is dedicated to all USBM employees who were part of the USBM family. *(See figure 15.)* Those who were on the rolls as September 1995 are listed below. They and those who served before them can take pride in their outstanding record of accomplishment and in having served America with the highest standards of quality and professionalism.

FIGURE 1
THE BUREAU SUPPLIED FEDERAL AGENCIES WITH HELIUM FOR PROJECTS RANGING FROM MEDICAL RESEARCH TO SPACE SHUTTLE FLIGHTS

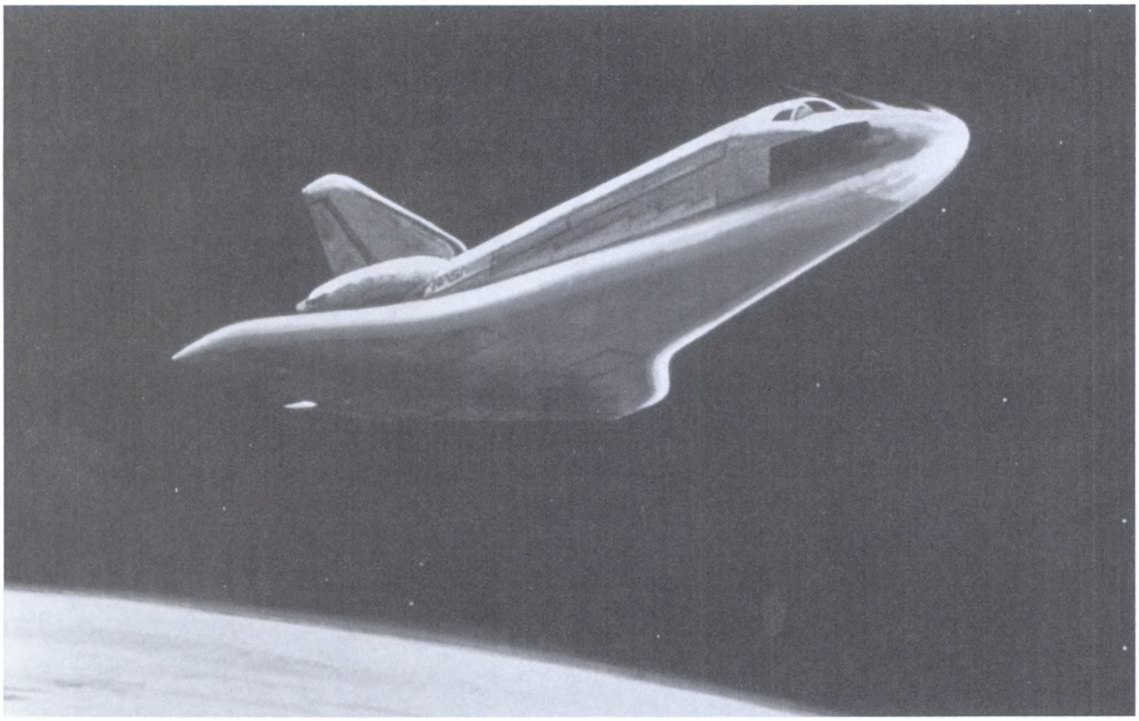


FIGURE 2
AT TIMES THE BUREAU SPANNED THE GLOBE WITH TECHNICAL EXPERTS STATIONED OVERSEAS AS MINERAL ATTACHES. THEIR DATA WERE INVALUABLE TO THE DEPARTMENTS OF DEFENSE AND STATE

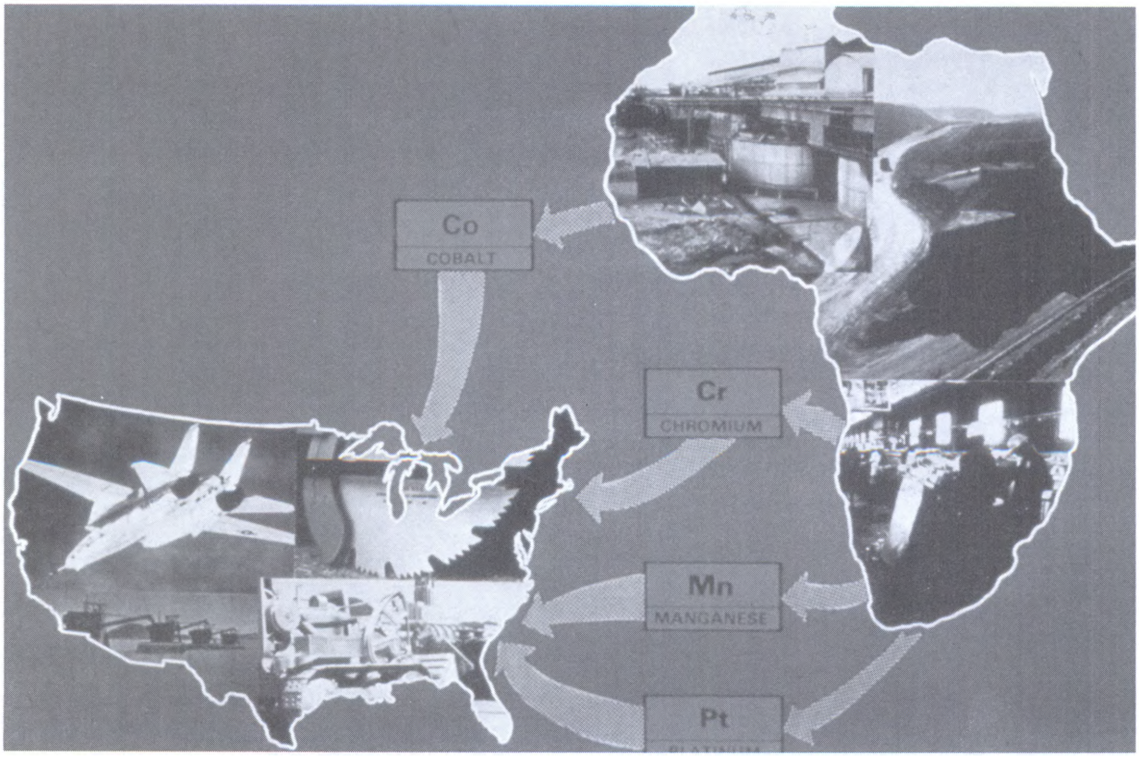


FIGURE 3
COAL MINE FATALITIES 1906-91

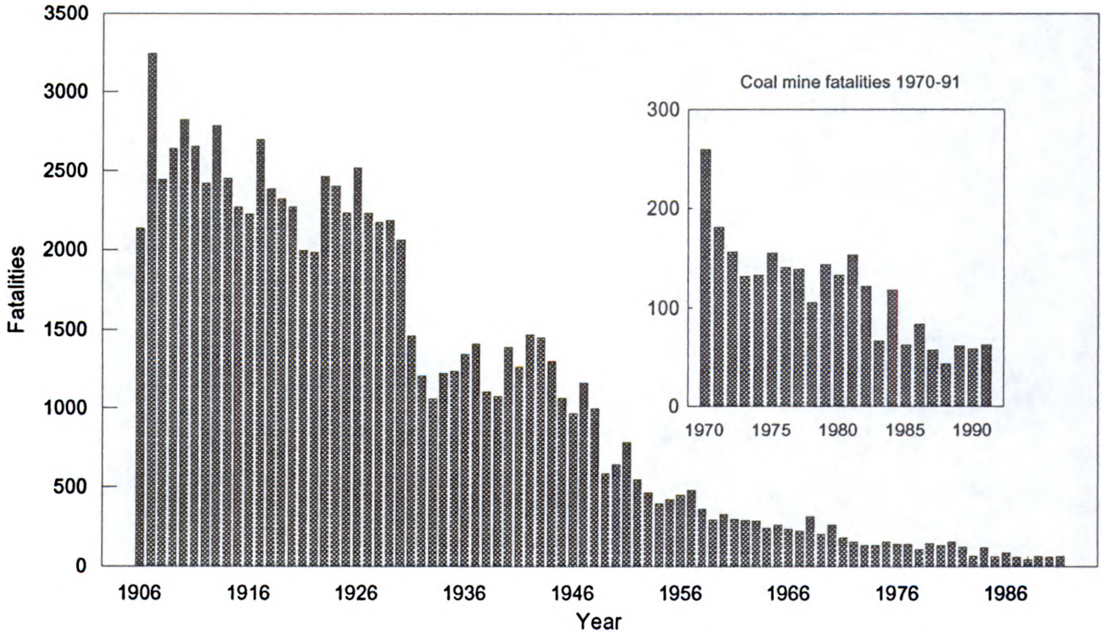


FIGURE 4
THE BUREAU CONDUCTED STUDIES ON MINE VENTILATION

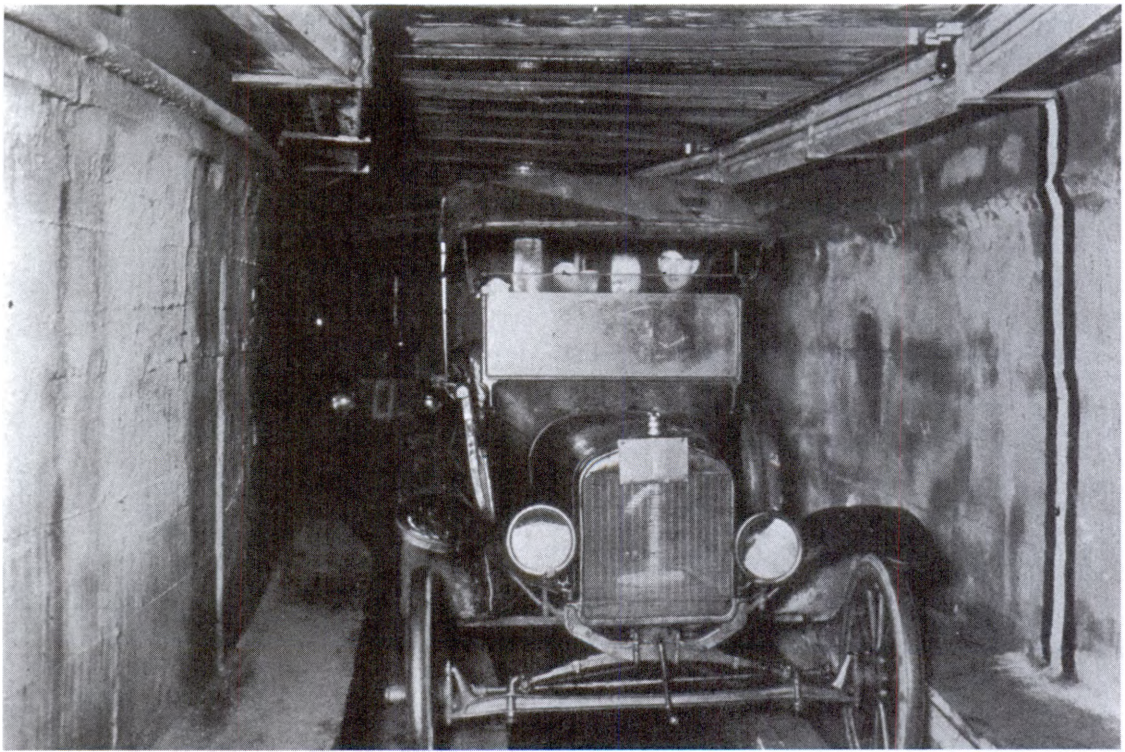


FIGURE 5
THE BUREAU'S ZIRCONIUM RESEARCH HELPED LAUNCH THE NUCLEAR NAVY

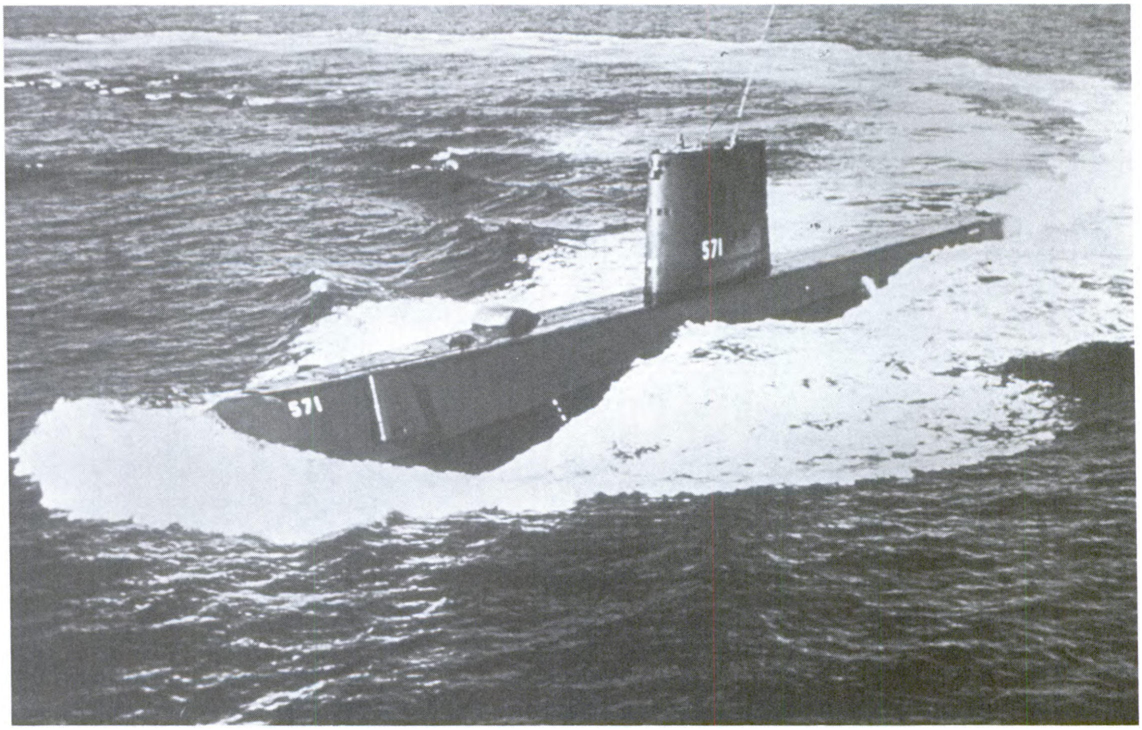


FIGURE 6
BUREAU RESEARCH ON IMPROVED GOLD RECOVERY REVITALIZED THE NATION'S GOLD INDUSTRY

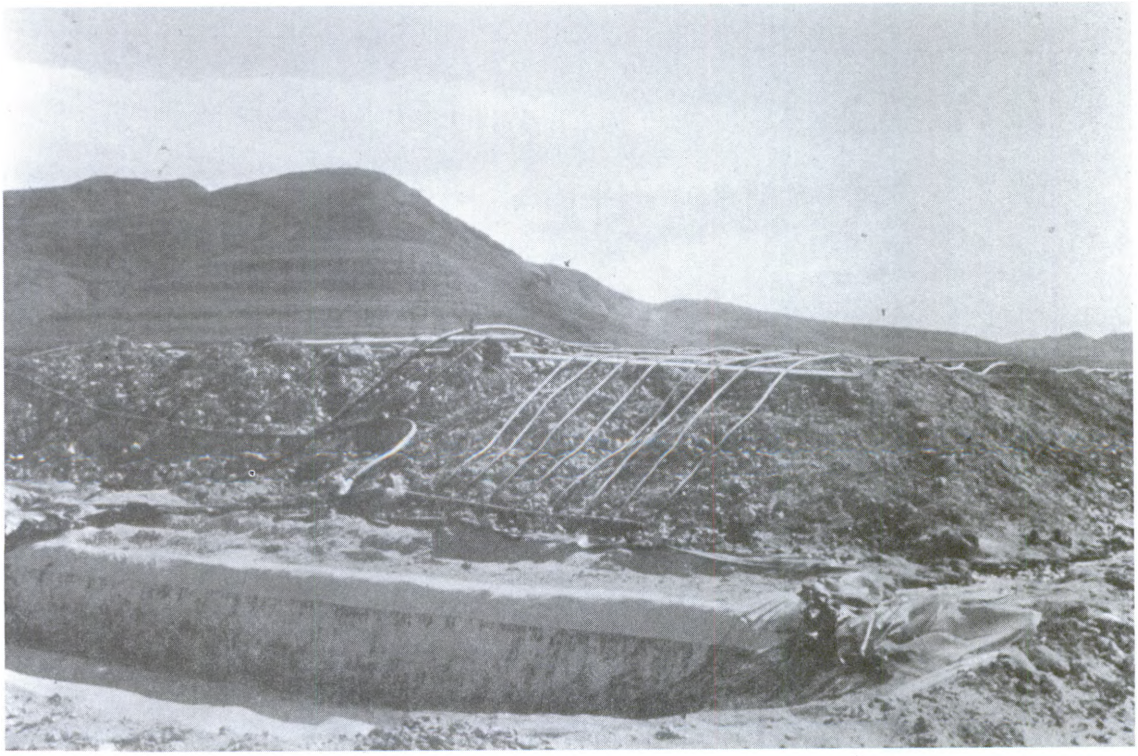


FIGURE 7
RESEARCH ON ACID MINE DRAINAGE HELPED HEAL MINING WOUNDS. TECHNOLOGIES, SUCH AS THE USE OF WETLANDS, TO TREAT ACID MINE DRAINAGE PROVIDED LOW-COST MEANS OF ENVIRONMENTAL RESTORATION

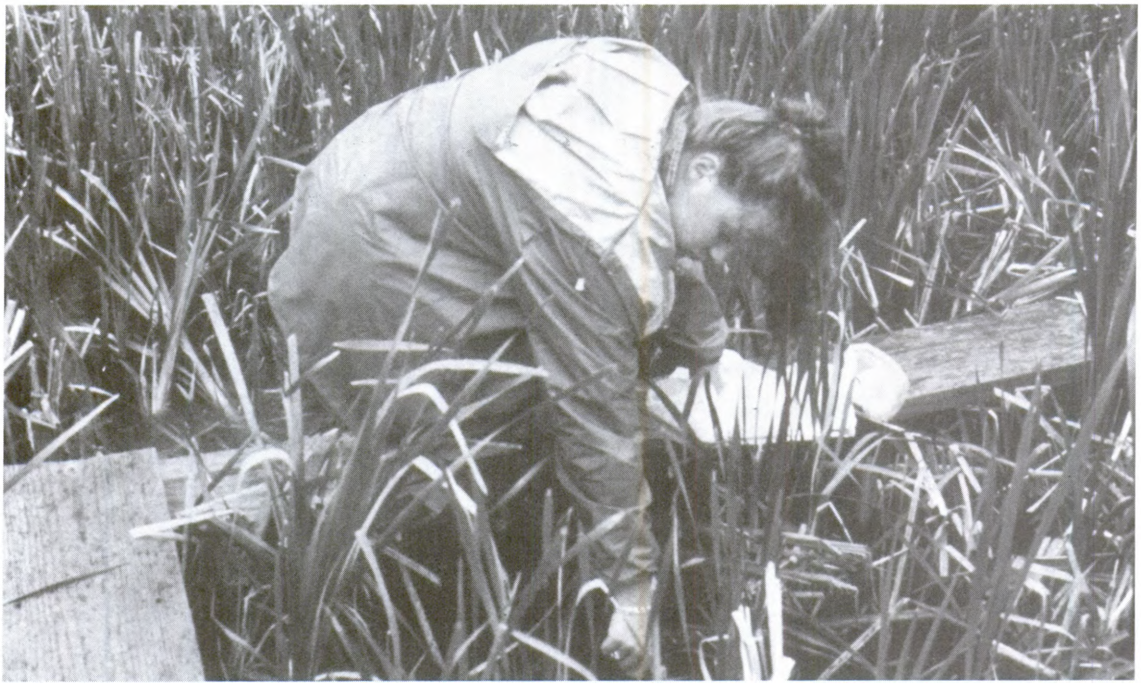


FIGURE 8
BUREAU RESEARCH HELPED TO PROTECT PERSONAL PROPERTY. BUREAU SCIENTISTS FOUND WAYS TO PREVENT THE SURFACE OF THE GROUND FROM SINKING OVER UNDERGROUND MINES

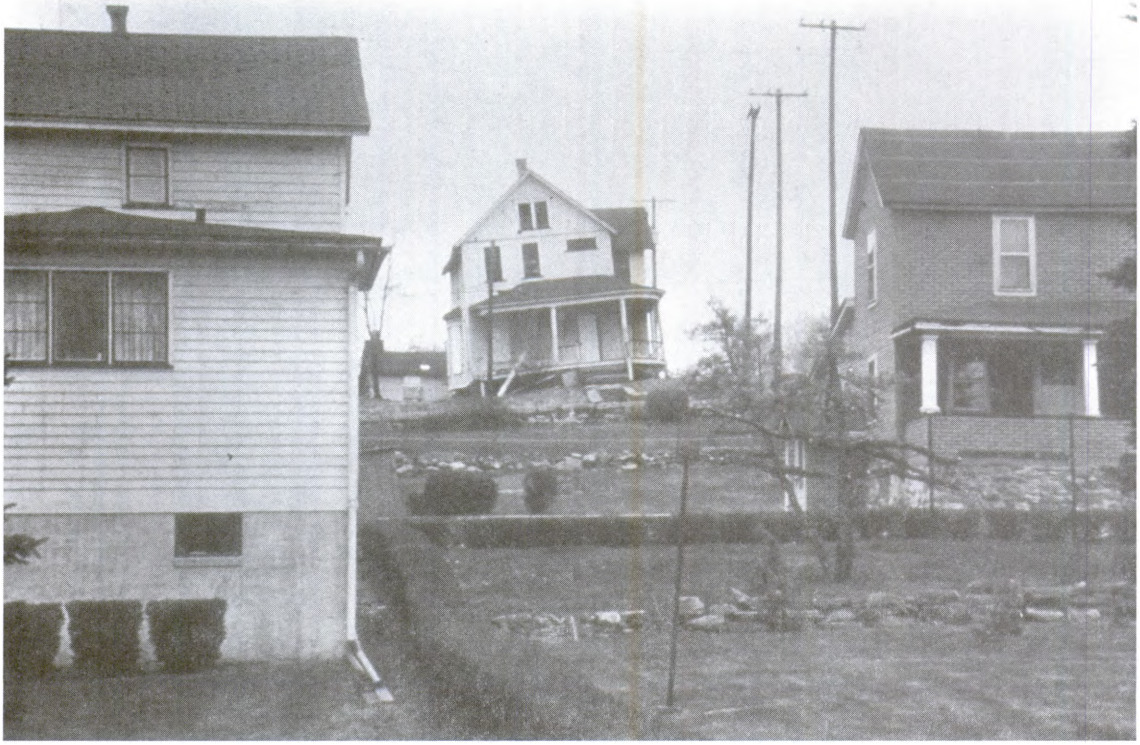


FIGURE 9
IRON MINING USES EQUIPMENT SUCH AS THIS

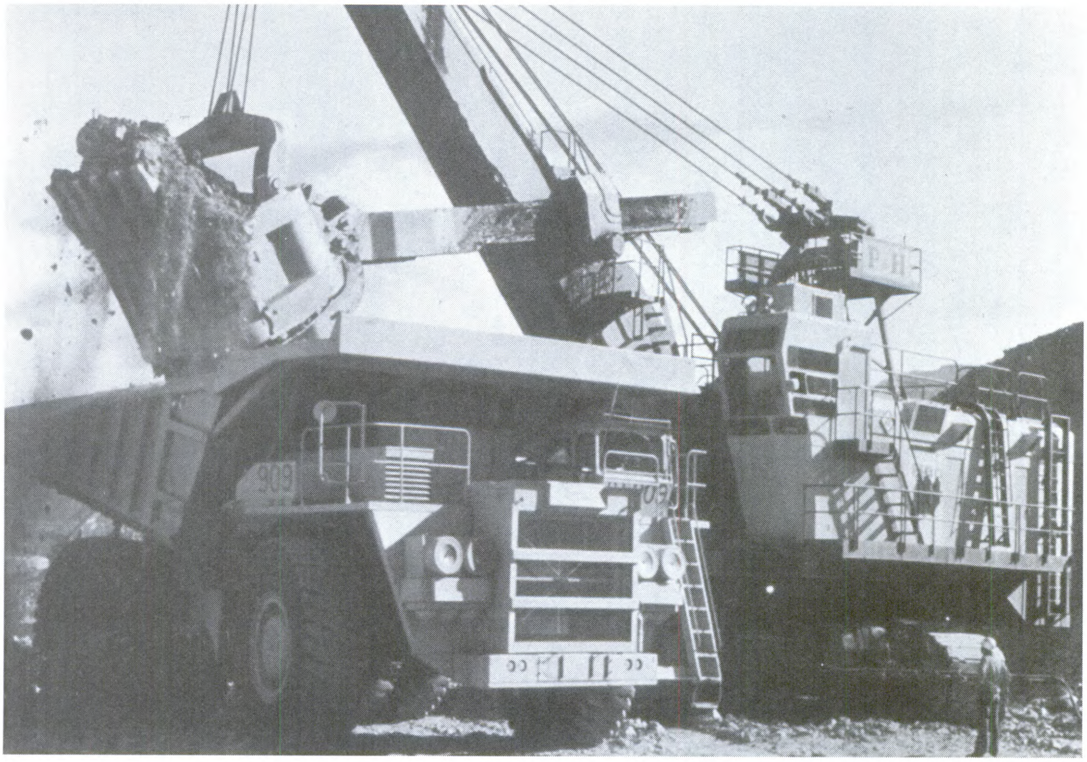


FIGURE 10
THE BUREAU PLAYED A MAJOR ROLE IN THE DISCOVERY OF THE RED DOG MINE, A WORLD CLASS LEAD-ZINC MINE

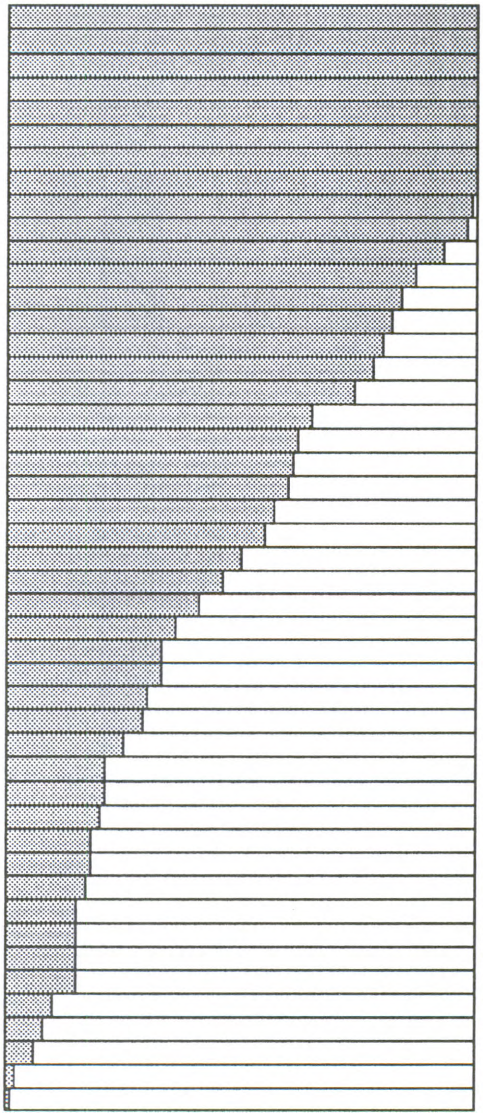
FIGURE 11
MINERAL INFORMATION FUNCTIONS OF THE BUREAU TRANSFERRED TO THE U.S. GEOLOGICAL SURVEY

MINERAL COMMODITY SUMMARIES 1986
MINERALS YEARBOOK
MINERALS YEARBOOK
MINERALS YEARBOOK
MINERAL FACTS AND PROBLEMS
PRIMARY ALUMINUM PLANTS WORLDWIDE
MINERAL INDUSTRY SURVEYS
MINERAL INDUSTRIES OF AUSTRALIA, CANADA, AND OCEANIA
NAMIBIA
ZAIRE
MINERAL INDUSTRIES OF EUROPE AND THE U.S.S.R.
MINERAL INDUSTRIES OF CHINA
ZIMBABWE
MINERAL INDUSTRIES OF THE U.S.S.R.
MINERAL INDUSTRIES OF THE MIDDLE EAST
The Chromium Industry of the U.S.S.R.

FIGURE 12

CHART SHOWS THE EXTENT THAT THE COUNTRY RELIED ON FOREIGN COUNTRIES FOR CRITICAL MINERALS

1995 U.S. NET IMPORT RELIANCE FOR SELECTED NONFUEL MINERAL MATERIALS



COMMODITY	PERCENT	MAJOR SOURCES (1991-94)
ARSENIC	100	China, Chile, Mexico
COLUMBIUM (niobium)	100	Brazil, Canada, Germany
GRAPHITE (natural)	100	Mexico, Canada, China, Madagascar, Brazil
MANGANESE	100	South Africa, Gabon, France, Brazil
MICA, sheet (natural)	100	India, Brazil, Finland, China
STRONTIUM (celestite)	100	Mexico, Germany
THALLIUM	100	Belgium, Canada, United Kingdom
YTTRIUM	100	China, United Kingdom, Hong Kong, Japan, France
BAUXITE and ALUMINA	99	Australia, Jamaica, Guinea, Brazil
GEMSTONES	98	Israel, India, Belgium, United Kingdom
FLUORSPAR	92	China, South Africa, Mexico
TUNGSTEN	87	China, Germany, Bolivia, Peru
TIN	84	Brazil, Bolivia, Indonesia, China
COBALT	82	Zambia, Norway, Canada, Zaire, Finland
TANTALUM	80	Australia, Germany, Canada, Thailand
CHROMIUM	78	South Africa, Turkey, Zimbabwe, Russia, Finland
POTASH	74	Canada, Belarus, Germany, Israel, Russia
BARITE	65	China, India, Mexico
IODINE	62	Japan, Chile
NICKEL	61	Canada, Norway, Australia, Dominican Republic
ANTIMONY	60	China, Mexico, South Africa, Hong Kong
STONE (dimension)	57	Italy, Spain, India, Canada
PEAT	55	Canada
MAGNESIUM COMPOUNDS	50	China, Canada, Mexico, Greece, Austria
ASBESTOS	46	Canada
ZINC	41	Canada, Mexico, Peru, Spain
DIAMOND (dust, grit & powder)	36	Ireland, China, Russia
SELENIUM	33	Canada, Philippines, Japan, Belgium, United Kingdom
SILICON	33	Norway, Brazil, Canada, Russia
GYPSUM	30	Canada, Mexico, Spain
PUMICE	29	Greece, Zaire, Turkey, Ecuador
ALUMINUM	25	Canada, Russia, Venezuela, Brazil
CADMIUM	21	Canada, Mexico, Belgium, Germany
IRON and STEEL	21	European Union, Canada, Japan, Brazil, South Korea
NITROGEN (fixed), AMMONIA	20	Trinidad and Tobago, Canada, Former Soviet Union, Mexico
IRON ORE	18	Canada, Brazil, Venezuela, Australia, Mauritania
SULFUR	18	Canada, Mexico
CEMENT	17	Canada, Spain, Greece, Venezuela, Mexico
LEAD	15	Canada, Mexico, Peru, Australia
SALT	15	Canada, Mexico, Bahamas, Chile
SODIUM SULFATE	15	Canada, Mexico
VERMICULITE	15	South Africa
MICA, scrap and flake (natural)	10	Canada, India
PERLITE	8	Greece
COPPER	6	Canada, Chile, Mexico
RARE EARTHS	2	Australia
LIME	1	Canada, Mexico

Additional commodities for which there is some import dependency include:

Bismuth	Mexico, Belgium, China, Peru	Platinum	South Africa, United Kingdom, Belgium, Germany
Gallium	France, Germany, Russia, United Kingdom, Hungary	Rhenium	Chile, Germany, United Kingdom, Russia, Kazakstan
Germanium	United Kingdom, Belgium, Germany, China	Rutile	Australia, Sierra Leone, South Africa
Ilmenite	South Africa, Australia, Canada	Silver	Mexico, Canada, Peru, Chile
Indium	Canada, France, Italy, Belgium, Russia	Thorium	Australia
Iron and steel slag	Canada, Japan	Titanium (sponge)	Russia, Japan, China
Kyanite	South Africa, France	Vanadium	Russia, South Africa, Canada, Mexico
Mercury	Canada, Russia, Germany	Zirconium	Australia, South Africa

FIGURE 13
U.S. MINERAL LOCATIONS IDENTIFIED IN THE MAS/MILS DATA BASE

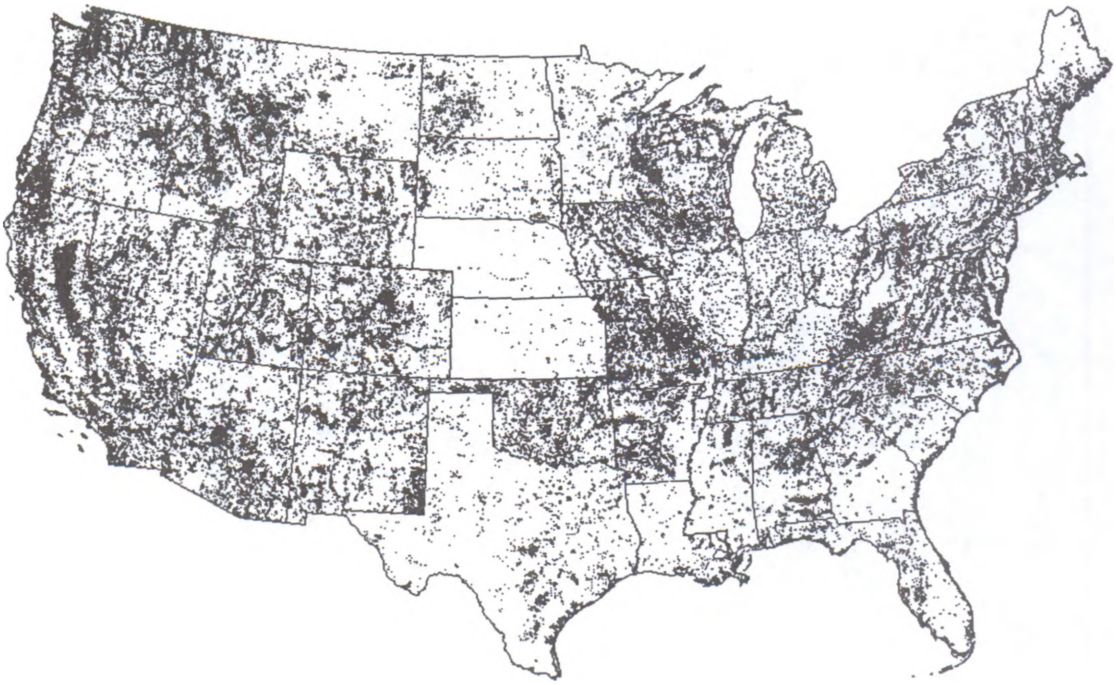


FIGURE 14
THE BUREAU SUPPLIED ITS EXPLORATION EXPERTISE TO INVENTORYING AND EVALUATING ABANDONED MINE SITES THAT LITTERED OUR PUBLIC LANDS

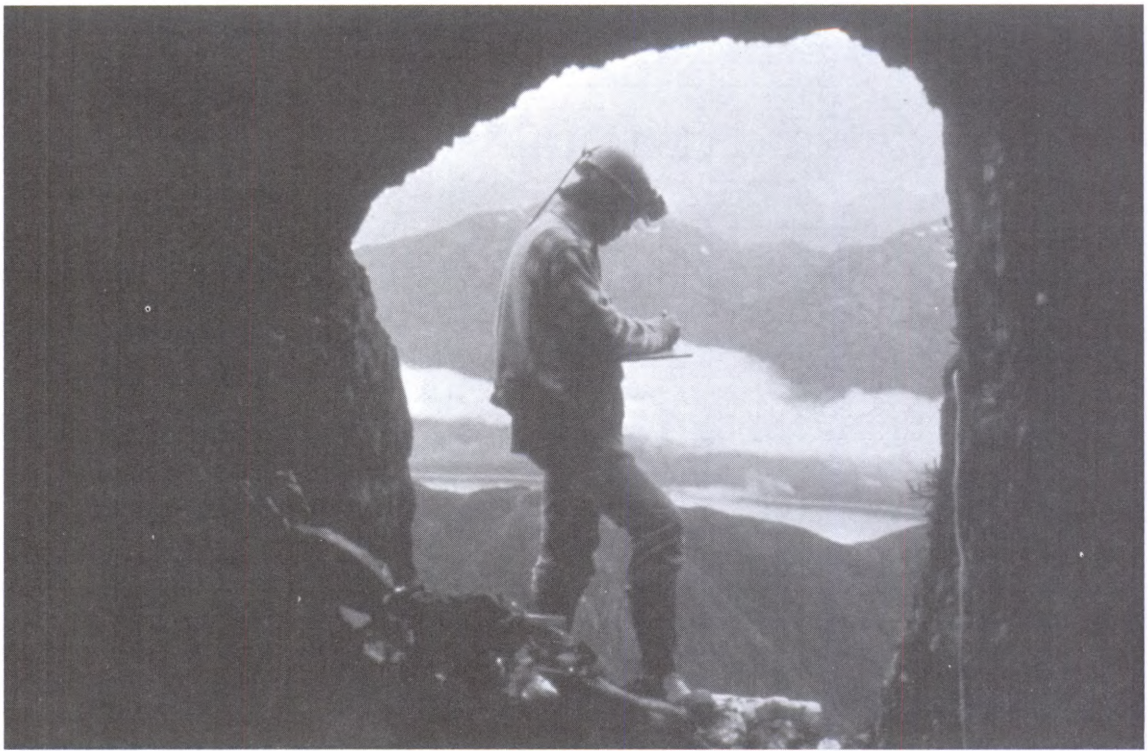


FIGURE 15
SOME OF THE PEOPLE TO WHOM THIS CHAPTER IS DEDICATED

BUREAU OF MINES EMPLOYEES AS OF SEPTEMBER 1995

Abruzzino, Angela M.
Acker, Mary Kay
Ackman, Marlene D.
Ackman, Terry E.
Achuff, Jonathan M.
Adams, Callestine E.
Adams, D. Jack
Adams, Michelle
Adams, Ricky J.
Adamson, Norman R.
Adler, Thomas A.
Adomshick, Paul
Ahlness, Jon K.
Akiyama, Diane K.
Albrecht, Jane S.
Alderdice, Linda
Aldinger, Jeffrey A.
Aljoe, William W.
Allen, James P.
Allgaier, Frederick K.
Alman, David E.
Almquist, Carl L.
Althaus, Richard T.
Alvarez, Linda L.
Amaro, Francisco
Amasino, Rosemarie
Ambrose, Dean H.
Amey, Earle B. III
Andersen, Marian J.
Anderson, Arlin W.
Anderson, Carl F.
Anderson, Clifton J.
Anderson, Donna L.
Anderson, Neal B.
Anderson, Ross F.
Anderson, Stephen T.
Anderson, Sterling J.
Angelo, Samuel E.
Angelos, Elizabeth
Anthony, Floyd
Antonides, Lloyd
Apodaca, Sheryl R.
Aragon, Roseann
Archibald, John H.
Argetsinger, Edward R.
Arguelles, Maria
Armstrong, Alyssa V.
Armstrong, Glynna R.
Armstrong, Robert
Arnold, Steven R.
Arrington, James M.
Asnicar, Dorothy J.
Aston, Sidney C.
Atkins, Anita A.
Atkinson, Gary B.
Atwood, Jeff V.
Au, Kalfred C. Y.
Aufmuth, Ray
Ausefski, David B.
Austin, Gordon T.
Avery, Dale W.
Ayres, Gary J.
Babcock, Nancy L.
Babich, Daniel R.
Backer, Ronald R.
Bacon, Kevin J.
Baer, Roger L.
Baggs, Donald W.
Baglin, Betty G.
Baileys, Rita Y.
Bailin, Idelle G.
Bajpayee, Tara S.
Baker, Delbert A.
Baker, Donald E.
Baker, Steve M.
Balazik, Ronald F.
BaldErrama, Robert M.
Balderston, Patricia
Baldwin, James H.
Balen, Michael D.
Ballard, Teresa L.
Barbour, Viola A.
Barczak, Thomas M.
Barnes, Floyd F.
Barnes, Melissa E.
Barnes, Thomas V.
Barnhart, Matt C.
Barrett, Edward A.
Barrett, Marie
Barron, Lance R.
Barry, Woody L.
Barsotti, Aldo F.
Bartels, John R.
Bartholomae, Roy C.
Barton, Timothy M.
Basante, Karla D.
Baskin, G. David
Bauer, Eric R.
Bauer, Paul G.
Baumann, Deanna L.
Baumann, Dianna L.
Bavido, James J.
Bazala, Eugene M.
Beard, H. Richard
Beasley, Beverly A.
Beasley, Bobby G.
Beatty, Nancy E.
Beckman, Kenneth A.
Beckwith, Doretha P.
Bedner, J. A.
Begley, Larry T.
Bell, Shawn L.
Benham, John R.
Benjamin, David A.
Benn, Freddy W.
Bennett, John B.
Bennett, Paul G.
Bennett, Richard M.
Benning, Monte N.
Berg, Andrew W.
Berglund, William R.
Beroni, Rena
Berry, David R.
Betonte, Ralph
Betz, D. Kae
Beus, Michael J.
Bevan, John E.
Beyke, Christine J.
Bhakta, Pragna N. H.
Bhanji, Noordin
Bhatt, Suresh K.
Bickel, Kenneth L.
Biddle, Holly R.
Biggs, Fred R.
Bigham, Terry L.
Billington, Selena
Bilski, Suzanne M.
Bird, Janet D.
Bishop, Charles A.
Bittenbender, Peter E.
Bittinger, Donald P. Jr.
Biviano, Marilyn B.
Black, Florence P.
Blackburn, Christine C.
Blackman, Leonard
Blackwell-Cornish, Denise
Blair, James R.
Blake, Rolland L.
Blake, Thelma J.
Blakely, M. Kay
Blamey, Stanley D.
Bleeker, Kerry E.
Bleiwas, Donald I.
Blossom, John W.
Bluemer, Debbie L.
Bockosh, George R.
Boff, V. L.
Bohrer, Allison L.
Boldt, Christine M. K.
Bolen, Wallace P.
Boleneus, David E.
Boler, Frances M.
Bolstad, Douglas D.
Bond, Melandie
Bonds, Linda M.
Boose, Angela Y.
Boreck, Donna L.
Borden, Linda A.
Boucher, Michael L.
Boudia, Rhonda G.
Bourque, Marji E.
Bowers, Ruth M.
Boyd, Douglas C.
Boyer, Thomas W.
Brady, Brian T.
Brady, Thomas M.
Branch, Wendy
Brandt, Theodore R.
Brautigam, Albert L.
Bredesen, Matthew A.
Breed, Dale D.
Breslin, John A.
Brickett, Lynn A.
Brink, Susan E.
Brnich, Michael J. Jr.
Brothers, Stacy
Brown, David S.
Brown, Allan L.
Brown, Patrick M.
Brown, Robert D. Jr.
Brown, Stephen D.
Bruce, Melvin (C)

Bruni, Patricia A.
Bryant, Kendra
Bryant, Sharon L.
Bryant, Tillit J.
Bryce, Kip E.
Buckingham, David A.
Buchwitz, James H.
Buehler, Alan R.
Bukkila, John G.
Bullard, Nelson R.
Bullard, Sophie J.
Bullard, Steven F.
Burfield, Marvin L.
Burks, J. Alton
Burma, Penny J.
Burnett-Hennek, LaRae G.
Burroughs, Renee Sharon
Burse, Ethel M.
Burton, Samuel R. M.
Bush, Richard P.
Busse, Jeffrey P.
Butchley, Dana L.
Butler, Charles M. Jr.
Butler, Faith R.
Butler, Keith H.
Butterman, William C.
Bynum, Imogene P.
Byrd, Terry L.
Cain, Jimmie D.
Calhoun, Roberta A.
Camm, Thomas W.
Campbell, Dale M.
Campbell, Harry W.
Campus, Nathan J.
Cannady, William H.
Cantrell, Bruce K.
Cantrell, Raymond L.
Capstick, Donald O.
Cardone, Carol R.
Carigiet, Annie
Carilli, Angela M.
Carlile, Kevin D.
Carlin, James F. Jr.
Carlis, JoAnn
Carlson, Elaine L.
Carnahan, Thomas G.
Carnes, R. David
Carolan, John J.
Carpenter, R. John
Carpenter, Wanda D.
Carrico, Linda C.
Carroll, Debra E.
Carroll, Nola R.
Carroll-Richardson, Elaine
Cashdollar, Kenneth L.
Caudle, Jerry D.
Causey, J. Douglas
Cawley, James C.
Cawthon, Deward L.
Cecala, Andrew B.
Chaiken, Robert F.
Chamberlain, Peter G.
Chambers, Albert J.
Chambers, Clarence Jr.
Chambers, John Jr.
Chambers, Michael F.
Chandler, Mark R.
Chanin, Lorne M.
Chang, Julius G.
Carolan, John J.
Chase, Frank E.
Chasko, Linda L.
Chatman, Mark L.
Chekan, Gregory J.
Chilton, Joseph E.
Chirban, Denise D.
Chovanec, Marie I.
Christiansen, R. Grey
Chufo, Robert L.
Claerhout, Scott R.
Clair, Deloris
Clancy, Timothy A.
Clare, M. Elizabeth
Clark, Andrea E.
Clark, Curtis C.
Clarke, Donald R.
Clemens, Elbert L.
Clemett, Betty N.
Cleva, Sandra J.
Cline, Ronald W. E.
Close, Terry J.
Coakley, George J.
Coberly, Jason W.
Coffelt, Janice L.
Cohen, Karen L.
Colarelli, Charles N.
Coldwell, James R.
Cole, Gregory P.
Coleman, Regina R.
Colinet, Jay F.
Coll, Steven R.
Collins, W. Keith
Colvin, Wade A.
Compton, Craig S.
Compton, Susan A.
Conaway, D. L.
Conger, Don M.
Connolly, Randall E.
Connor, Kevin
Connors, Steven W.
Conover, David P.
Conti, Ronald S.
Cook, Albert H.
Cook, Colleen S.
Cook, Irvin C.
Cooper, Angela R.
Cooper, Wymar G. II
Copeland, Charles R.
Copeland, Susan (C)
Coppa, Luis
Cordova, Conrad G.
Cornelius, David E.
Cornelius, Dorothy L.
Cornelius, Kim M.
Cornell, William L.
Cornellisson, Joseph L.
Cortese, Robert A.
Corwin, Richard R.
Costello, LuJean J.
Cottle, Gladys F.
Covino, Bernard S. Jr.
Cox, Dennis J.
Cox, Robert
Cox, Ryan L.
Coyle, Kevin M.
Coyne, Jannie L.
Crabtree, Laura L.
Craig, Lorna L.
Cramer, Stephen D.
Crandell, William D.
Craney, Judy E.
Crawford, Cheryl J.
Creech, Danny L.
Crespin, Fred
Cress, Glynn O.
Crews, Carolyn F.
Crotsley, Rose Ann
Crum, Steven V.
Cullen, Elaine T.
Cumerlato, Calvin L.
Cunningham, Curtis G.
Cunningham, Larry D.
Curtin, Richard P.
Curtis, Richard G.
Cusick, Brenda L.
Daellenbach, Charles B.
Dahl, Linda J.
Dahlby, Howard B.
Dahlin, David C.
Daley, Michael R.
Dalverny, Louis E.
Daly, Daniel W.
Daniel, J. Harrison Jr.
Dattilo, Marion
Daves, Joel D.
David, Charles F. Jr.
Davidoff, Robert L.
Davidson, Charles F.
Davidson, Robert A.
Davidson, Thomas A.
Davis, Carl B.
Davis, Daniel L.
Davis, Emma K.
Davis, Jeanne M.
Davis, John D.
Davis, Mary E.
Davis, Wannette E.
De La Rosa, Joe G.
Dean, Nancy E.
DeAnda, Conrad R.
Debsikdar, Jagadish C.
DeCesare, Roger S.
Delzingaro, David J.
DeMarco, Matthew J.
Denlinger, R. Wayne
Denton, David K.
Deringer, Richard W.
DeRosa, Maria I.
Deshotel, Robert W.
DeVeaux, Joseph L.
Deveney, Kathleen M.
DeVliegher-Munson, Stefanie
Dia, Nabil S.
Diamond, Susann
Diamond, William P.
Dietrich, Carol
Dietz, Marybeth
DiFrancesco, Carl A.
DiGrado, Paul E.
Dillon, John T.
DiMartino, Michael D.
Dinatale, Anthony
Dix, Russell B.
Dixon, Eraina C.
Djahanguiri, Farrokh
Doan, David B.
Doan, Randy C.
Dobroski, Harry Jr.
Dockery, Tiffany M.
Dockins, Dana L.
Doepker, Richard D.
Doering, Carol L.
Dogan, Cynthia P.
Dolgos, Joseph G.
Dolinar, William J.
Dolinar, Dennis R.

Dolley, Thomas P.
Dolzani, Roger L.
Donahue, James F.
Donato, Douglas A.
Dooley, George J. III
Dorris, Les R.
Dottin, David A.
Douglas, Cheryl D
Dowgiert, Susan K.
Downey, Constance L.
Doyle, Robert E. Jr.
Dragseth, Gary K.
Drake, Pamela L.
Draper, Roy F.
Drescher, Andrew
Drescher, Theodore A.
Driscoll, Cynthia E.
Driskill, David L.
Droullard, Robert F.
Drozell, Stanley M.
Drumm, Eric C.
Dubaniewicz, James E.
Dubaniewicz, Thomas H. Jr.
DuCarme, Joseph P.
Duchene, Les J.
Duchon, James C.
Duda, Frank T. Jr.
Duerr, Wayne H.
Dugan, Thomas D.
Dunaway, Janelle L.
Dunford, John P.
Dunkelberger, Eric (C)
Dunlap, Dorothy B.
Dunn, Cindy L.
Dunn, James R.
Dunn, Michael D.
Dunning, John S.
Dunnington, Erma E.
Dupree, Jean A.
Durheim, Roger M.
Durr, Thomas M.
Durrant, Joyce K.
Duttlinger, Neal W.
Dvorak, Darryl H.
Dwyer, David L.
Dysinger, Dan K
Earley, Dusty
Easley, Martha A.
East, Joan H.
Eaton, Barbara L.
Eckert, Robert J.
Eddington, Richard A.
Edelstein, Daniel L.
Edenborn, Harry M.
Edgerton, Justin R.
Edwards, David L.
Edwards, Evette (C)
Edwards, John C.
Edwards, John C.
Edwards, John C.
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Ellett, Mindee K.
Elliott, W. Kay
Elliott, Gene V.
Ellis, Clarence E.
Ellison, Larry C.
Else, Ronald G.
Enzer, Hermann
Erickson, Paul R.
Erickson, Harlan D.
Erickson, Susan M.
Eslinger, Kermit K.
Esparza, Leon E.
Esplin, Douglas N.
Esprit, Darryl J.
Estey, Louis H.
Eue, Jason S.
Evans, Linda
Ewell, Mary
Fairbank, Bonnie B.
Fantel, Richard R.
Farrier, Cynthia L.
Fay, Jody M.
Federspiel, Francis E.
Felice, Diane M.
Felix, Dennis P.
Fenton, Michael
Ferderer, David A.
Ferguson, Chris R.
Ferguson, William B.
Ferri, Chris (C)
Fibich, A. Lawrence
Field, William H.
Filigenzi, Marc T.
Finfinger, Gerald L.
Firewick, David
Fischer, George F. W.
Fish, Gayle C. (C)
Fisher, Beverly E.
Fisher, Jerry T.
Fisher, Sheree D.
Fisher, Thomas J.
Fleming, Karen M.
Fletcher, Sheron L.
Fligg, Kendall S.
Flinn, David R.
Floyd, Alice J.
Flusche, Paul
Foley, Jeff Y.
Fondren, Randall L.
Fong, Janet M.
Ford, John D.
Fortier, Gregory A.
Foss, Maureen M.
Foster, Russell J.
Fotta, Barbara
Fouquette, Jay M.
Fowkes, Richard S.
Fox, Gina M.
Fraley, Jack E.
Frampton, Bret J.
Franke, Dean F.
Franken, Kristopher M.
Franks, Robert A.
Fraser, Sam J.
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Frazier, Karen F.
Fredrickson, Ted W.
Free, Kyle L.
Freeman, Evelyn
Freeman, Patrick A.
Friedel, Michael J.
Frieders, Twila Y.
Friel, Gene F.
Fries, Edward F.
Frieze, Edward B.
Frippel, Michel C.
Froisland, Lawrence J
Fross, Teresa M.
Fuller, Carl C.
Fulton, Barbara J.
Furno, Aldo L.
Gabby, Peter N.
Gage, Brent D.
Gage, John D.
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Gallagher, Jamie
Gallagher, Sean
Gallardo, Katie S.
Galvan, Gloria J.
Gambogi, Joseph
Garbowsky, Calvin D.
Gardutte, Bonnie R.
Garcia, Fred
Gardner, Kenneth R.
Gardner, Ted H.
Garone, Anthony
Garrett, Charlotte G.
Gassaway, Cheryl
Gaston, Cicely (C)
Gauna, Marion R. Jr.
Gbruoski, John S.
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Gensler, Edward C.
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Geraghty, John J.
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Gese, Diann D.
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Gifford, Shelby L.
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Gilmore, Beth L.
Ginley, Douglas M.
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Glass, Daniel L.
Glod, Tracy L.
Gloster, Mildred E.
Glover-Cox, Sunday R.
Glowacki, Audrey F.
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Goggins, John W.
Goldbach, Tracy L.
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Gomez, Mark R.
Gonzales, Ben A.
Goodman, Gerrit V. R.
Goonan, Thomas G.
Gorman, Michael G.
Gosliak, Kathleen
Govier, R. Dale
Grabowski, Richard B.
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Grantham, Allen A.
Grau, Roy H. III
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Greeley, Michael N.
Green, Elizabeth E.
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Green, Gregory M.
Green, G. Kyle
Greninger, Nevin B. Jr.
Greuer, Rudolf E.

Gribben, Clara J.
Gribben, Timothy P.
Griffin, Russell E.
Griffith, Carolene R.
Griffith, Debra A.
Griffith, Terrill L.
Gritton, Kenneth S.
Grocke, Carol
Grove, R. B.
Gruber, Gloria S.
Gudger, Sherri R.
Guess, Larry E.
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Gurmendi, Alfredo C.
Guthrie, Randy J.
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Hall, Laurice G.
Hall, Robert R.
Hamak, John E.
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Hamilton, Timothy H.
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Hammack, Robin A.
Hammargren, Dwight D.
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Handrahan, George W.
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Hansen, Carie A.
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Hanson, David R.
Haramy, Khamis Y.
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Harbuck, Donna
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Hardy, Elizabeth A.
Harjanne, Rita A.
Harkess, Joyce E.
Harkins, John S.
Harley, Lisa D.
Harmel, Robert M.
Harper, Virginia C.
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Harris, Keith L.
Harris, Sheri L.
Harrison, Demetris T.
Harrison, Donald K.
Harrison, Marcus D.
Harrod, Vicki
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Hartfelder, Don L.
Hartinger, George V.
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Hauser, Kenneth L.
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Hawley, Nadine R.
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Hays, Deborah L.
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Heasley, Keith A.
Hebble, Terry L.
Hedrick, James B.
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Helton, Bobby D.
Hemphill, Evangeline J.
Henderson, William
Henning, Patricia A.
Henry, John R.
Henry, Leonard G.
Herforth, Barbara L.
Hermes, John W.
Hernandez, Fernando Jr.
Heydari, Michael Mir
Hibpshman, Mark H.
Hice, Frances N.
Hickly, Teresa R.
Hicks, Gary W.
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Higgins, L. Glynn
Higgis, Elvatoria E.
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Hilliard, Henry E.
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Hinderliter, Donald L.
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Hirota, Donald K.
Hirt, William C.
Hite, Alan G.
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Hofeldt, David L.
Holcomb, Gordon
Holderfield, Sonja P.
Holland, Philip W.
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Holmes, Lorraine
Holtgrefe, Daniel G.
Holub, Robert F.
Homce, Gerard T.
Homs, Patricia A.
Hood, Gwendolyn D.
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Horter, Glenn L.
Hoskins, Darrell P.
Houck, Gerald W. Jr.
Hougen, David G.
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Hughes, Deborah
Hundley, Gary L.
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Hurd, Emily T.
Hurdelbrink, Ronald J.
Hustwit, Craig C.
Hwang, Charles C.
Hyde, Garrett R.
Hyman, David M.
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Ingram, David K.
Inman, Kirsten L.
Inniss, Gloria E.
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Izon, David
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Jackson, Gary W.
Jackson, Kenneth W.
Jackson, Michael J.
Jackson, Robert S.
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Jacobson, Ferril R.
Jacobson, Jolene
James, Delores L.
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James, Lori G.
James, Mei Lee
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Jansky, Jacqueline H.
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Jasinski, Stephen M.
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Jeran, Paul W.
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Johnson, Daneene M.
Johnson, David D.
Johnson, Deborah E.
Johnson, Don R.
Johnson, Edward E.
Johnson, Fredrick L.
Johnson, Guy A.
Johnson, Jeffrey C.
Johnson, Jerold L.
Johnson, Jon E.
Johnson, Kent
Johnson, Paul W.
Johnson, Robin
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Johnston, Joanne L.
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Jolly, Arthur F.
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Jones, Fredrick M.
Jones, Lois
Jones, Marilyn C.
Jones, Odessa N.
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Jones, Richard J.
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Jones, Thomas S.
Jordan, Cy E.
Jordan, Eric N.
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Joseph, Seva J.
Judd, John C.
Jude, Charles V.
Kaas, L. Michael
Kadnuck, Liane
Kaiser, Robin C.
Kalmik, Tina L.
Kalyoncu, Rustu S.
Kane, William F.
Kaplan, Robert S.

Karnack, Frank A.
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Keeling, Maraline J.
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Kellner, Henry J. Jr.
Kelly, Thomas D.
Kennedy, Harold R. Jr.
Keran, Christopher M.
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Kernan, James A.
Kertis, Carla A.
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Keys, Kathy D.
Kiermas, Ronald S.
Kilau, Howard W.
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Killen, Sean M.
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Kimbrough, Samuel C.
Kimbrough, William F.
King, Grant L.
King, Michael E.
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Kirk, William S.
Kirch, Jeffrey D.
Kirschner, Fred E.
Kissell, Fred N.
Klein, Barry W.
Kleinhampl, R. E.
Kleinhenz, John W.
Kleinmann, Robert L.
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Knoch, Debora L.
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Knutsen, Galen C.
Ko, Hon-Chung
Koch, John N.
Kociban, Andrew M.
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Koehler, John R.
Kohli, Deepak
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Kopp, John W.
Korzeb, Stanley L.
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Kostick, Dennis S.
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Kouzes, Jerry L.
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Kramer, Billie L.
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Kripakov, Nicholas P.
Kroening, Joesph G.
Kuck, Peter H.
Kuczynski, Robert J.
Kuenzi, Joan K.
Kugel, Roger W.
Kunicki, Raymond G.
Kuo, Chin S.
Kurtak, Joseph M.
Kusumi, Henry N.
Kwitowski, August J.
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Lamars, Joy M.
Lamberson, Rodney S.
Lambeth, Robert H.
Lampshire, Dan L.
Lane, Michael E.
Langhans, Debby L.
Langhans, John W.
Lankford, John R.
Lansberry, Pansy L.
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Larsen, Robyn G.
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Larson, Mark K.
LaScola, John C.
Latham, Joyce E.
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Laughery, Donald E.
Laws, Katherine J.
Layman, Laureen K.
Lazzara, Charles P.
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Ledvina, Christophe
Lee, Diane F.
Lee, John W. Jr.
Lee, June T.
Lee, Robert
Leeper, Merton D.
Leftridge, Darlene
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Lemons, John S.
Lenart, Patricia J.
Leszcykowski, Andrew M.
Leuschen, Wendy D.
Levens, Russell L.
Levine, Richard M.
Lewellyn, Joseph C.
Lewis, Andrea I.
Lewis, Max C.
Lewis, William H.
Lichtman, Kenneth E.
Lien, Richard H.
Light, Charles M. Jr.
Limberg, Marta L.
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Lindsay, Christopher
Lindsey, David S.
Linne, James M.
Lipapis, Christy N.
Lipton, David A.
Listak, Jeffrey M.
Litchfield, John C.
Litton, Charles D.
Lockard, David W.
Lockman, William T. Jr.
Loebenstein, J. Roger
Lombardi, John A.
Longwill, Warren D.
Lopez, Jeanette D.
Lord, Anna D.
Love, Robert W.
Lowanse, Deborah A.
Lowe, Nathan T.
Lucci, Carrie E.
Lucki, Herbert P.
Luginbhyl, Joyce M.
Lundeen, Daniel C.
Luster, Charles "Kevin"
Lutz, Leonard J.
Lutz, Timothy J.
Lutzens, William W.
Lyday, Phyllis A.
Lyday, Travis Q.
Lym, Paulette B.
Lyman, Jane W.
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Mack, Cheryl M.
Mackay, William C.
Mackritis, Helen
Mades, Joel F.
Madsen, Brent W.
Madsourivong, Phongs
Magers, Jeff
Maggs, Kevin J.
Magyar, Michael J.
Mainiero, Richard J.
Maiterth, Robert A.
Makowski, Barbara D.
Mal, Thomas
Maleki, Hamid
Mallett, Launa G.
Mamales, Michael P.
Mangum, Rickey L.
Mann, David (C)
Manns, Christina R.
Maranda, Jim S.
Marchetti, K. T.
Mardock, Cheryl L.
Mares, Neal P.
Marjaniemi, Darwin K.
Mark, Christopher
Marshall, John K.
Marshall, Rovondia L.
Marshall, Stephanie F.
Marshall, Thomas E.
Martin, Cindy S.
Martin, Clay M.
Martin, David R.
Martin, Eddie
Martin, Eileen M.
Martin, Lewis A.
Martin, Lyndal R.
Martin, Thomas W.
Martinez, Aquilino O.
Martinez, Shannon E.
Mason-Thomas, Gail
Mason, Joyce A.
Matetic, Rudy J.
Mathison, Peter K.
Matos, Grecia R.
Matragas, Sheila B.
Matson, Craig R.
Matthes, Steven A.
Matty, Timothy J.
May, James P.
Mayercheck, William D.
Mayerle, Ronald T.
Mayfield, F. Marie
Mayfield, Joe
Mayton, Alan G.
McAchren, Susan A.
McCall, Frank E.
McClain, Judy M.
McClaskey, Jacqueline
McClure, B. Tom

McCorkle, Marci A.
McCormick, Sammy P.
McCoy, Hugh L.
McCubbin, L. Jeanne
McDonald, JoAnn L.
McDonald, Joseph F.
McDonald, W. Richard
McDonnell, John R. Jr.
McDowell, Barbara
McElhinney, Patrick
McGaa, John R.
McGee, Dana M.
McGinnis, Libby L.
McHugh, Edward L.
McIntosh, Synthia N.
McKean, Thomas H.
McKewan, William M.
McKibbin, Robert W.
McKinley, Michael J.
McKinney, Melba R.
McMahon, Terrance J.
McNair, Barbara J.
McNeil, James R.
McNutt, Paul
McRae, William (C)
McQueen, Revondra
McSurdy, Sandra L.
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Meyer, Mark P.
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Meyers, Joseph H.
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Milanovich, Jeff (C)
Miles, James
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Millenacker, Daniel
Miller, Arthur L.
Miller, Gregory G.
Miller, M. Michael
Miller, Marianne
Miller, Michael S.
Miller, Mildred C.
Miller, Nadia
Miller, Phillip C.
Miller, Richard Jr.
Miller, W. F.
Miller, William L.
Mills, Dennis W.
Mills, J. M.
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Miscoe, Anthony J.
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Mitchell, Cyrus (C)
Mitchell, Dan D.
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Mitchell, Kimberly A.
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Moore, Bruce W.
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Moore, Ricky L. Sr.
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Morecock, Robert Jr.
Moreno, Daniel C.
Morgan, Stanley J.
Morrell, Roger J.
Morrin, Sally L.
Morris, Lisa N.
Morris, Tony E.
Morrow, Gerald S.
Morse, David E.
Mory, Peter C.
Moser-Karstens, Daw
Moulder, Phyllis
Mowrey, Gary L.
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Mularski, Margaret L.
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Mundell, R. Lindsay
Muniz, Nick (C)
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Nelson, Bruce C.
Nelson, Debra A.
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Nilsen, David N.
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Noel, Linda R.
Nolan, Debra (C)
Noll, Barbara B.
Nonini, Lewis G.
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Ochs, Thomas L.
Oddenino, Charles
Oden, Laurance L.
Oestreich, John M.
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Oliver, Frank S.
Olsen, Richard S.
Olson, Donald W.
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Olson, Keith S.
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Opfer, Donna M.
Opferman, John J.
Opyrchal, Anthony M.
Organiscak, John A.
Ornot, Carl T.
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Osborne, Shonta E.
Oshiver, Sherry J.
Osmint, Jeffrey
Osmonson, Lee M.
Oswald, John G.
Otterness, Rolfe E.
Owens, John K.
Owens, Judith F.
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Palmer, Ronnie H.
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Pappas, Deno M.
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Patel, Amit (C)
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Pendergraft, Sandra K.
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Perky, Walter K.
Perry, Allen O.
Perry, Janice A.
Perry, Joseph A.
Perry, Mercedes K.
Persetic, George F.
Persichini, Belita J.

Peters, Alysee V.
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Peterson, Gary R.
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Peterson, Joseph B.
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Peterson, Orin M.
Peterson, Robin S.
Peterson, Stanley R.
Peterson, Teri L.
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Pettus, Martha L.
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Phillips, Thomas
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Pierce, Willard E. II
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Pollock, Douglas E.
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Pomroy, William H.
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Porter, Doris A.
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Price, Judith A.
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Pritchard, Glenn C.
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Prokop, Alexander D. III
Prosser, Leonard J. Jr.
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Quinn, Almeta
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Rau, Jean L.
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Rawers, James C.
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Recker, Denise A.
Redden, Lorin D.
Reed, Shonell R.
Reese, Robert G. Jr.
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Rehak, Timothy R.
Reigel, Larry C.
Reinard, R. D.
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Rice, Allen W.
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Ripple, Wanda L.
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SURVEY METHODS

By Jacqueline A. McClaskey

The U.S. Bureau of Mines (USBM) Information and Analysis Directorate collects worldwide data on virtually every commercially important nonfuel mineral commodity. These data form the base for tracking and assessing the health of the minerals sector of the U.S. economy.

The USBM data collection activity was instituted by the 47th Congress in an appropriations act of August 7, 1882 (22 Stat. 329), which placed the collection of mineral statistics on an annual basis. The most recent authority for the USBM survey activity is the National Materials and Minerals Policy, Research and Development Act of 1980 (Public Law 96-479, 96th Congress). This act strengthens protection for proprietary data provided to the U.S. Department of the Interior by persons or firms engaged in any phase of mineral or mineral-material production or consumption.

Data Collection Surveys

The USBM begins the collection of domestic nonfuel minerals and materials statistics by appraising the information requirements of Government and private organizations of the United States. Requirements that can be met by collecting data from minerals establishments are posed as questions on USBM surveys. Figure 1 shows a typical survey form.

Specific questions about the production, consumption, shipments, etc. of mineral commodities are structured in the survey forms to provide meaningful aggregated data. Thus, the entire mineral economic cycle from production through consumption is covered by 146 monthly, quarterly, semiannual, and annual surveys.

After the survey form has been designed, a list of the appropriate establishments to be canvassed is developed. Many sources are used to determine which companies, mines, plants, and other operations should be included on the survey mailing list. State geologists, Federal organizations (e.g., Mine Safety and Health Administration), trade associations, industry representatives, and trade publications and directories are some of the sources that are used to develop and update survey listings. With few exceptions, a complete canvass of the list of establishments is employed rather than a sample survey. The iron and steel scrap industry is one of the exceptions where a sample survey is conducted.

The Paperwork Reduction Act requires that any Government agency wishing to collect information from 10 or more individuals or establishments first obtain approval from the Office of Management and Budget (OMB). OMB approves the need to collect the data and protects industry from unwarranted Government paperwork. *(See figure 1.)*

Survey Processing

The USBM surveys approximately 25,000 establishments. Each year the USBM mails about 42,500 forms that gather information for 146 different surveys. Each completed survey form returned to the USBM undergoes extensive scrutiny to ensure the highest possible accuracy of the mineral data. The statistical staff monitors all surveys to ensure that errors are not created by reporting in physical units different from the units requested on the form. Relationships between related measures, such as produced crude ore and marketable crude ore, are analyzed for consistency. Engineering relationships, such as recovery factors from ores and concentrates, also are employed. The totals for each form are verified, and currently reported data are checked against prior reports to detect possible errors or omissions.

For the majority of the surveys, which are automated, the forms are reviewed to ensure that data are complete and correct before entering into the computer. The computer is programmed to conduct a series of automated checks to verify mathematical consistency and to identify discrepancies between the data reported and logically acceptable responses.

The USBM is modernizing and automating all of its survey processing and data dissemination functions. Automated commodity data system functions include computerized preparation of statistical tables; the use of desktop publishing to integrate text and tables; and electronic dissemination through a bulletin board system and the Internet. Also, information on minerals and mineral-related publications is now available through an easy-to-use automated facsimile (fax) response system known as MINES FaxBack.

Survey Responses.--To enable the reader to better understand the basis on which the statistics are calculated, each commodity annual report includes a section entitled "Domestic Data Coverage." This section briefly describes the data sources, the number of establishments surveyed, the response percentage, and the method of estimating the production or consumption for nonrespondents.

To produce reliable aggregated data, the USBM employs efficient procedures for handling instances of nonresponse. Failure to return the initial survey form results in a second mailing of the form. If the second form is not returned, telephone calls are made to the nonrespondents. The followup calls provide the necessary data to complete the survey forms and/or verify questionable data entries. Periodic visits to important minerals establishments also are made by USBM commodity specialists to gather missing data and to explain the importance of the establishment's reporting. By describing the use of the published statistics and showing the impact of nonresponse, the USBM strives to encourage respondents to give a complete and accurate reply.

The OMB "Guidelines for Reducing Reporting Burden" stipulates that the minimum acceptable response rate shall be 75% of the panel surveyed. In addition, the USBM strives for a minimum reporting level of 75% of the quantity produced or consumed (depending on the survey) for certain key statistics. Response rates are periodically reviewed. For those surveys not meeting the minimum reporting level, procedures are developed and implemented to improve response rates.

Estimation for Nonresponse.--When efforts to obtain a response to a survey fail, it becomes necessary to employ estimation or imputation techniques to account for missing data. These techniques are most effective when the response rate is relatively high. Some of the estimation methods depend on knowledge of prior establishment reporting, while other techniques rely on external information to estimate the missing data. When survey forms are received after the current publication has been completed, the forms are edited, necessary imputations are made for missing data, and the survey data base is updated. The revised data are reported in later publications.

Protection of Proprietary Data.--The USBM relies on the cooperation of the U.S. minerals industry to provide the mineral data that are presented in this and other USBM publications. Without a strong response to survey requests, the USBM would not be able to present reliable statistics. The USBM in turn, respects the proprietary nature of the data received from the individual companies and establishments. To ensure that proprietary rights will not be violated, the USBM analyzes each of the aggregated statistics to determine if the data reported by an individual establishment can be deduced from the aggregated statistics. If, for example, there are only two significant producers of a commodity in a given State, the USBM will not publish the State total because either producer could readily estimate the production of the other. It is this obligation to protect proprietary information that results in the "Withheld" or "W" entries in the published tables. However, if a company gives permission in writing, the USBM will publish the data as long as the data from other respondents are protected from disclosure.

International Data

International data are collected by country specialists in the USBM Division of International Minerals with assistance from the Section of International Data. The data are gathered from various sources, including published reports of foreign Government mineral and statistical agencies, international organizations, the U.S. Department of State, the United Nations, the Organization of Petroleum Exporting Countries, and personal contact by specialists traveling abroad. Each February, an annual "Minerals Questionnaire" is sent through the Department of State to more than 70 U.S. embassies asking them to provide estimates of mineral production for the host country for the preceding year. Missing data are estimated by USBM country specialists based on historical trends and specialists' knowledge of current production capabilities in each country.

Publications

The USBM disseminates current and historical minerals information through a broad range of printed publications.

The Minerals Yearbook summarizes annually, on a calendar-year basis, the significant economic and technical developments in the mineral industries. Three separate volumes are issued each year: Volume I, Metals and Minerals; Volume II, Area Reports, Domestic; and Volume III, Area Reports, International. Chapters in Volume I are issued separately as Mineral Industry Surveys (MIS) before the bound volume is available. Volume I of the Minerals Yearbook presents, by mineral commodity, salient statistics on production, trade, consumption, reserves, and other measures of economic activity. Volume II of the Minerals Yearbook reviews the U.S. minerals industry by State and island possessions. Volume III of the Minerals Yearbook contains the latest available mineral data for the year of review on more than 185 foreign countries and discusses the importance of minerals to the economies of these nations.

Mineral Industry Surveys contain timely statistical and economic data on minerals. The surveys are designed to keep Government agencies and the public, particularly the mineral industry and the business community, informed of trends in the production, distribution, inventories, and consumption of minerals. Frequency of issue depends on the demand for current data. Mineral Industry Surveys are released monthly, quarterly, semiannually, or annually.

Mineral Commodity Summaries, an up-to-date summary of about 80 nonfuel mineral commodities, is the earliest Government publication to furnish estimates covering the previous year's nonfuel mineral industry data. It contains information on the domestic industry structure, Government programs, tariffs, 5-year salient statistics, and a summary of international mining news.

Metal Industry Indicators, published monthly, contains indexes that measure the current and future performance of four U.S. minerals industries. For each of the four industries, a composite coincident index and a composite leading index have been developed based on procedures and data similar to those used to construct the U.S. Department of Commerce's coincident and leading cyclical indicators for the national economy.

Information Circulars are primarily concerned with USBM economic reviews and interpretative analyses. The series also includes surveys of mining and operating activities, guides to marketing of mineral commodities, and compilations of historical information and statistical and economic data on minerals.

Order free copies of the Mineral Industry Surveys or the Metal Industry Indicators from Publication Distribution, U.S. Bureau of Mines, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236, (412) 8992-4338.

To purchase Minerals Yearbooks and Mineral Commodity Summaries, order from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, (202) 783-3238.

Information Circulars and Mineral Commodity Summaries also may be purchased from the National Technical Information Service, Springfield, VA 22161, 1-800-553 NTIS (in Virginia and foreign countries: 1-703-487-4650).

Some Bureau publicatons are also available on a CD-ROM format. The CD-ROM is updated on a quarterly basis. It is available from the Government Printing Office at the number listed above.

Electronic Data Dissemination

In addition to the USBM's printed publications, current Mineral Industry Surveys for all commodities are now available through the USBM bulletin board system. Using this system, the public may obtain information up to 4 weeks before published copies of the reports would arrive in the mail. The system may be accessed by calling (202) 501-0373 using a modem set to

1200 or 2400 baud, 8 data bits, no parity, and 1 stop bit. Further information on how to use the MINES-DATA system may be obtained from the system operator by calling (202) 501-0406.

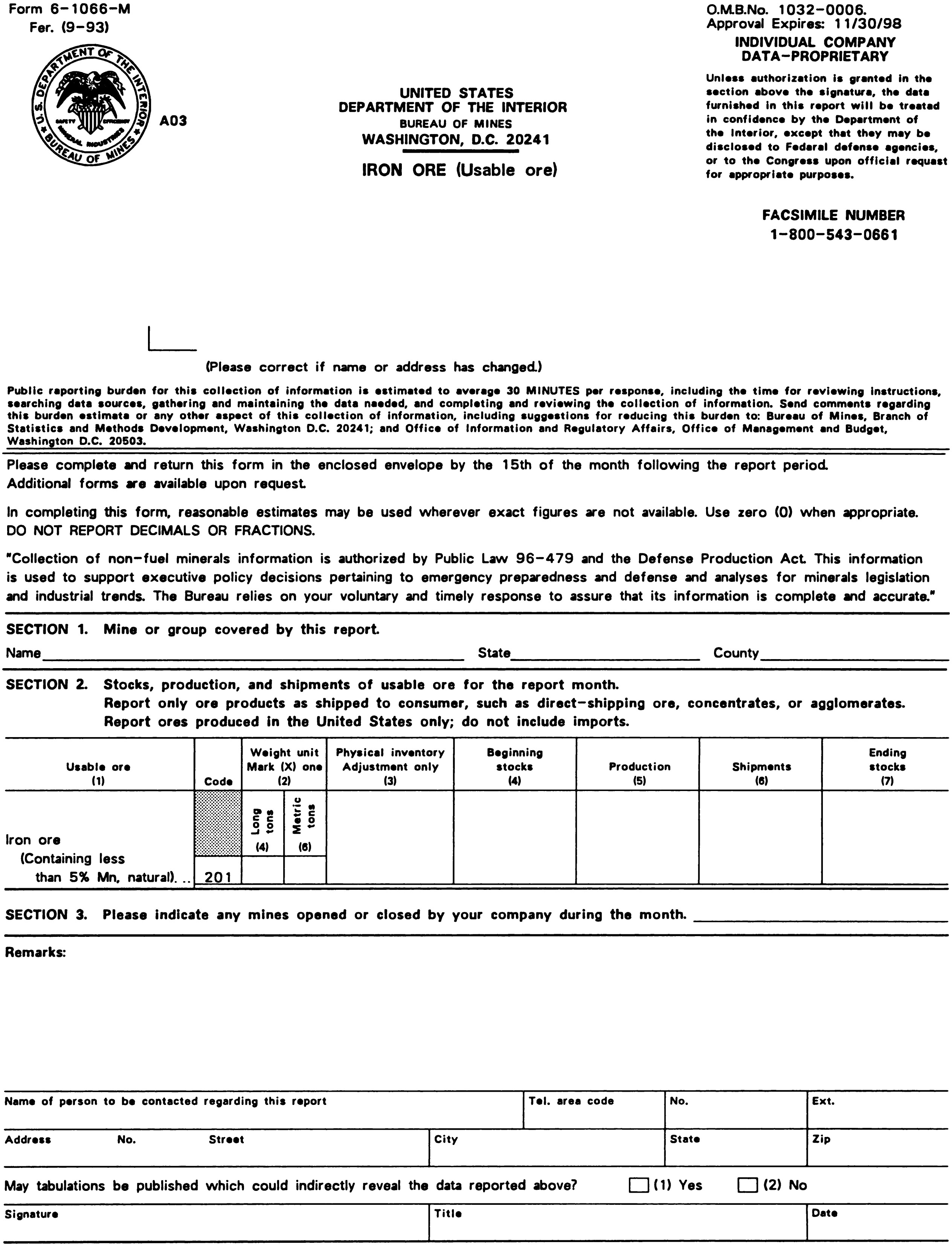
Also, current information on minerals and mineral-related publications from the USBM is now available through an easy-to-use automated facsimile response system. The MINES FaxBack service allows callers to retrieve information and order some publications for delivery to their fax machines in minutes, 24 hours per day, 7 days per week. MINES FaxBack makes monthly and quarterly Mineral Industry Surveys publications available to the public at the same time they are forwarded to the printer.

MINES FaxBack works from any Group III-compatible fax machine equipped with a touch-tone telephone (either a built-in handset with touch-tone capability or a separate touch-tone telephone plugged into the fax machine's phone jack). After calling MINES FaxBack, the requestor is guided by a series of voice messages that assist the caller in ordering the desired documents. The caller pays for the phone call that also includes the time needed to deliver the requested document to the caller's fax machine.

To access the MINES FaxBack System, use a touch-tone handset attached to a fax machine or connect a touch-tone telephone to the fax machine's telephone jack and dial (202) 219-3644. Listen to the menu options and select an option using the touch-tone telephone. After completing a selection, press the start button on the fax machine.

The Bureau also has a page on the World Wide Web detailing the Bureau's mission, products, and accomplishments. To access the page, use Netscape or a similar Web browser. The URL is http://www.usbm.gov. The page also contains links to the Bureau's gopher and other mining-related pages on the internet.

FIGURE 1
A TYPICAL SURVEY FORM



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DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D.C. 20241

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Public reporting burden for this collection of information is estimated to average 30 MINUTES per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: Bureau of Mines, Branch of Statistics and Methods Development, Washington D.C. 20241; and Office of Information and Regulatory Affairs, Office of Management and Budget, Washington D.C. 20503.

Please complete and return this form in the enclosed envelope by the 15th of the month following the report period. Additional forms are available upon request.

In completing this form, reasonable estimates may be used wherever exact figures are not available. Use zero (0) when appropriate. DO NOT REPORT DECIMALS OR FRACTIONS.

"Collection of non-fuel minerals information is authorized by Public Law 96-479 and the Defense Production Act. This information is used to support executive policy decisions pertaining to emergency preparedness and defense and analyses for minerals legislation and industrial trends. The Bureau relies on your voluntary and timely response to assure that its information is complete and accurate."

SECTION 1. Mine or group covered by this report.

Name________________ State________________ County________________

SECTION 2. Stocks, production, and shipments of usable ore for the report month.
Report only ore products as shipped to consumer, such as direct-shipping ore, concentrates, or agglomerates.
Report ores produced in the United States only; do not include imports.

Usable ore (1)	Code	Weight unit Mark (X) one (2)		Physical inventory Adjustment only (3)	Beginning stocks (4)	Production (5)	Shipments (6)	Ending stocks (7)
		Long tons (4)	Metric tons (6)					
Iron ore (Containing less than 5% Mn, natural). ..	201							

SECTION 3. Please indicate any mines opened or closed by your company during the month. ________________

Remarks:

Name of person to be contacted regarding this report		Tel. area code	No.	Ext.
Address No. Street	City		State	Zip

May tabulations be published which could indirectly reveal the data reported above? ☐ (1) Yes ☐ (2) No

Signature	Title	Date

STATISTICAL SUMMARY

By Stephen D. Smith

This annual report summarizes data on crude nonfuel mineral production for the United States, its island possessions, and the Commonwealth of Puerto Rico. Also included in this report are tables that show the principal nonfuel mineral commodities exported from and imported into the United States. In addition, there is a table that compares world and U.S. mineral production for selected nonfuel mineral commodities. The detailed data from which these tables were derived are contained in the individual commodity and State Annual Reports published by the U.S. Bureau of Mines.

Although crude mineral production may be measured at any of several stages of extraction and processing, the stage of measurement used in this annual report is what is termed "mine output." This term refers to minerals or ores in the form in which they are first extracted from the ground, but customarily may include the output from auxiliary processing at or near the mines.

Because of inadequacies in the statistics available some series deviate from the foregoing definition. For the commodities of copper, gold, lead, silver, tin, and zinc, the quantities shown are recorded on a mine basis (as the recoverable content of ore sold or treated). However the values assigned to the quantities are based on the average selling price of refined metal, not the mine value. Mercury is measured as recovered metal and valued at the average New York price for the metal. Values shown are in current dollars, with no adjustments made to compensate for changes in the purchasing power of the dollar.

The total value of all nonfuel mineral production in the United States increased about 10% to $35.2 billion in 1994, with metals increasing almost 12% to $12.1 billion and industrial minerals rising approximately 9% to $23.0 billion over that of 1993. Eight of the mineral commodities produced in the United States in 1994 had an individual total production value greater than $1 billion. These commodities in decending order, stone (crushed and broken); cement (portland); copper; gold; sand and gravel (construction); clays; iron ore; and lime; comprised over 78% of the U.S. total production. (*See table 1.*)

Eleven States in 1994 produced mineral commodities having an individual total production value of greater than $1 billion. These States in decending order, Arizona; Nevada; California; Georgia; Texas; Utah; Michigan; Florida; Minnesota; Missouri; and Pennsylvania; comprised over 56% of the U.S. total production. (*See table 4.*)

U.S. exports of mineral commodities in 1994 decreased slightly overall, with metals decreasing almost 6% to $21.4 billion, and industrial minerals increases of over 17% to $5.1 billion. Imports into the United States increased more than 21%, with metals increasing over 26% to $34.2 billion, and industrial minerals increased 7% to $11.1 billion over that of 1993. (*See tables 8 and 9.*)

TABLE 1
NONFUEL MINERAL PRODUCTION 1/ IN THE UNITED STATES 2/

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS							
Beryllium concentrates	metric tons	4,830	$5	4,940	$5	4,330	$5
Copper 3/	do.	1,760,000	4,180,000	1,800,000	3,640,000	1,810,000	4,430,000
Gold 3/	kilograms	330,000	3,660,000	331,000	3,840,000	326,000 4/	4,040,000 4/
Iron ore	thousand metric tons	55,600	1,730,000	56,300	1,640,000	57,600	1,580,000
Iron oxide pigments (crude)	metric tons	39,300	4,670	35,800	5,020	46,400	6,010
Lead 3/	do.	397,000	307,000	355,000	249,000	363,000	298,000
Magnesium metal	do.	137,000	360,000	132,000	377,000	128,000	389,000
Mercury	do.	64	376	W	W	W	W
Molybdenum 5/	do.	49,600	209,000	39,200	165,000	46,000	284,000
Nickel ore 6/	do.	6,670	W	2,460	W	--	--
Palladium	kilograms	6,470	18,100	6,500	25,300	6,440	29,400
Platinum	do.	1,840	21,100	1,800	21,400	1,960	25,300
Silver 3/	metric tons	1,800	229,000	1,650	227,000	1,480	252,000
Zinc 3/	do.	523,000	674,000	488,000	497,000	570,000	619,000
Combined value of antimony, bauxite, manganiferous ore (5% to 35%), rare-earth metal concentrates, tin (1992-93), titanium concentrates (ilmenite and rutile), tungsten, vanadium, zircon concentrates, and values indicated by symbol W		XX	151,000	XX	132,000 r/	XX	147,000
Total metals		XX	11,500,000	XX	10,800,000 r/	XX	12,100,000
INDUSTRIAL MINERALS (EXCLUDING FUELS)							
Asbestos	metric tons	15,600	6,140	13,400	5,960	10,100	5,120
Barite	thousand metric tons	326	19,600	315	19,300	583	21,700
Boron minerals (B2O3)	metric tons	1,010,000	339,000	1,050,000	373,000	1,110,000	443,000
Bromine e/	do.	171,000	170,000	177,000	123,000	W	W
Cement:							
Masonry	thousand metric tons	2,660	195,000	2,960	229,000	3,610	286,000
Portland	do.	66,100	3,500,000	71,600	3,920,000	74,300	4,460,000
Clays	do.	40,700	1,480,000	40,700 r/	1,470,000 r/	42,200	1,600,000
Diatomite	metric tons	595,000	141,000	599,000	150,000	613,000	153,000
Feldspar	do.	726,000	28,500	770,000	31,400	765,000	31,200
Garnet (abrasive)	thousand metric tons	54	4,840	W	W	42	15,100
Gemstones		NA	66,200	NA	57,700	NA	50,500
Gypsum (crude)	thousand metric tons	14,800	101,000	15,800	107,000	17,200	115,000
Helium:							
Crude	million cubic meters	W	W	29	25,800	39	38,500
Grade-A	do.	94	187,000	96	189,000	100	199,000
Iodine	metric tons	2,000	20,900	1,940	15,400	1,630	12,800
Lime	thousand metric tons	16,200	950,000	16,800 r/	965,000 r/	17,400	1,020,000
Mica (scrap)	do.	85	4,640	88	4,450	110	7,280
Peat	do.	652	16,700	612	16,800	552	15,300
Perlite	metric tons	541,000	16,400	569,000	17,400	644,000	19,400
Phosphate rock	thousand metric tons	47,000	1,060,000	35,500	759,000	41,100	839,000
Potash (K2O equivalent)	do.	1,770	334,000	1,640	286,000	2,970	285,000
Pumice	metric tons	481,000	14,900	469,000	12,000	490,000	11,800
Salt	thousand metric tons	34,800	803,000	38,700	893,000	39,500	956,000
Sand and gravel:							
Construction	do.	834,000	3,340,000	869,000	3,530,000	891,000	3,740,000
Industrial	do.	25,200	434,000	26,200	454,000	27,300	488,000
Silica stone 7/	metric tons	1,730	239	528	330	514	3,990
Sodium compounds:							
Soda ash	thousand metric tons	9,380	836,000	8,960	734,000	9,320	724,000
Sodium sulfate (natural)	do.	337	26,300	W	W	298	11,400
Stone: 8/							
Crushed	do.	1,050,000	5,590,000	1,130,000 r/	6,030,000 r/	1,230,000	6,620,000
Dimension	metric tons	981,000	181,000	1,230,000	216,000	W	W
Sulfur (Frasch)	thousand metric tons	2,600	159,000	1,900	101,000	3,010	162,000
Tripoli	metric tons	84,900	3,260	94,000	4,090	82,300	10,900
Vermiculite	do.	190,000	15,100	187,000	14,900	177,000	14,200
Zeolites	do.	W	NA	41,000	NA	58,000	NA

See footnotes at end of table

TABLE 1 -- Continued
NONFUEL MINERAL PRODUCTION 1/ IN THE UNITED STATES 2/

Mineral	1992		1993		1994	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS (EXCLUDING FUELS) -- Continued						
Combined value of brucite, calcium chloride [natural 9/ (1992)], emery, fluorspar, greensand marl, kyanite, lithium minerals, magnesite, magnesium compounds, olivine, pyrites 10/ (1992-93) sand and gravel (construction), staurolite, talc and pyrophyllite, wollastonite, and values indicated by symbol W	XX	$525,000	XX	$422,000 r/	XX	$692,000
Total industrial minerals	XX	20,600,000	XX	21,200,000 r/	XX	23,000,000
Grand total	XX	32,100,000	XX	32,000,000 r/	XX	35,200,000

e/ Estimated. r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" data.
XX Not applicable.

1/ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Recoverable content of ores, etc.

4/ Placer canvassing discontinued beginning 1994. May include some placer data from other sources.

5/ Content of ore and concentrate.

6/ The Riddle nickel smelter uses lateritic ore mined on Nickel Mountain, lateritic ore imported from New Caledonia, and small tonnages of recycled Ni-bearing catalysts. In 1989, the Glenbrook Nickel Co. purchased the idle mining and smelting complex and restarted the operation. Production of ferronickel on a contained Ni basis has been as follows: 1992--8,962 metric tons (mt) valued at $62.7 million; 1993--4,878 mt valued at $28.0 million; and in 1994 the Nickel Mountain mine was idle.

7/ Formerly identified as "abrasives". Includes grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

8/ Excludes abrasive stone and bituminous limestone and sandstone; all included elsewhere in table.

9/ Canvassing discontinued beginning 1993.

10/ Canvassing discontinued beginning 1994.

TABLE 2
TOTAL U.S. NONRENEWABLE ORGANIC MATERIALS PRODUCTION, BY QUANTITY AND VALUE 1/ 2/

(Million metric tons unless otherwise specified)

Category	1992		1993		1994	
	Quantity	Value (millions)	Quantity	Value (millions)	Quantity	Value (millions)
Asphalt and road oil	25.30	$2,800	27.20	$2,690	(3/)	(3/)
Lubricants, waxes, and miscellaneous products	12.40	1,530	12.70	1,370	(3/)	(3/)
Petrochemical industries	66.60	7,540	66.00	6,820	(3/)	(3/)
Petroleum coke and coal	12.70	1,110	12.90	986	(3/)	(3/)
Total	117.00	13,000	119.00	11,900	(3/)	(3/)

1/ Quantities valued at the fossil fuel prices given in the Department of Energy, Energy Information Administration, Annual Energy Review 1992.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Coverage discontinued beginning 1994.

Note: Nonrenewable organic materials represent all nonfuel uses in physical structure applications. The petrochemical industries category includes feedstocks for the production of plastics, synthetic rubber, synthetic fibers, pesticides, coatings, solvents, fertilizers, and other petrochemicals.

TABLE 3
NONFUEL MINERALS PRODUCED IN THE UNITED STATES, BY COMMODITY AND STATES IN 1994

(Based on quantity unless otherwise noted)

Mineral	Principal States	Other States
Antimony 1/	ID	
Asbestos	CA and VT	
Barite	GA, NV, MO, MT,TN, IL	
Bauxite	AL and GA	
Beryllium concentrate	UT	
Boron minerals	CA	
Bromine e/	AR	
Brucite	NV	
Cement:		
Masonry	FL, IN, AL, MD, SC, PA	All other states except AK, CT, DE, LA, MA, MN, MS, NV, NH, NJ, NC, ND, OR, RI, VT, WI, WY.
Portland	CA, TX, MI, PA, MO, AL	All other states except AK, CT, DE, LA, MA, MN, NH, NJ, NC, ND, RI, VT, WI.
Clays	GA, WY, FL, CA, MS, TN	All other states except AK, DE, HI, ID, RI, VT, WI.
Copper 1/	AZ, UT, NM, MT, MI, WI	ID, IL, MO, NV, OR, and TN.
Diatomite	CA, NV, WA, OR	
Emery	OR	
Feldspar	NC, CA, VA, GA, OK, ID	SD
Fluorspar	IL	
Garnet (abrasive)	ID and NY	
Gemstones (natural) 2/	TN, AR, AL, KY, AZ, MT	All other states.
Gold 1/ 3/	NV, CA, UT, SD, MT, WA	AK, AZ, CO, ID, NM, OR, SC, WI.
Greensand	NJ	
Gypsum (crude)	OK, MI, IA, TX, NV,IN	AR, AZ, CA, CO, IN, KS, LA, NM, NY, OH, UT, VA, WY.
Helium (crude and Grade-A)	KS, WY, TX, UT, CO	
Iodine	OK	
Iron ore (usable) 4/	MN, MI, MO, UT, TX, SD	CA, MI, NM
Iron oxide pigments (crude)	MO, GA, MI, VA, AZ	
Kyanite	VA	
Lead 1/	MO, AK, ID, MT, CO, NY	IL and TN.
Lime	OH, MO, PA, AL, KY, TX	All other states except AK, CT, DE, FL, GA, HI, KS, ME, MD, MS, NH, NJ, NM, NY, NC, RI, SC, VT.
Lithium minerals	NC and NV	
Magnesite	NV	
Magnesium compounds	MI, DE, FL, CA, UT, TX	
Magnesium metal	TX, WA, UT	
Manganiferous ore	SC	
Mercury	NV, UT, CA	
Mica (scrap)	NC, GA, NM, SC, SD	
Molybdenum	AZ, CO, UT, MT, ID, NM	
Nickel ore	OR	
Olivine	WA and NC	
Palladium metal	MT	
Peat	MI, FL, MN, IL, ME, NC	CO, IA, ME, MA, MT, NJ, NY, ND, OH, PA, SC, WA, WV, WI.
Perlite	NM, AZ, CA, NV	
Phosphate rock	FL, NC, ID, UT	
Platinum metal	MT	
Potash	NM, UT, CA, MI	
Pumice	CA, OR, AZ, NM, KS, ID	
Pyrites (ore and concentrate)	(5/)	
Rare-earth metal concentrates	CA and FL	
Salt	NY, OH, LA, KS, MI, TX	AL, AZ, CA, NV, NM, OK, UT, WV.
Sand and gravel:		
Construction	CA, TX, OH, AZ, WA, MI	All other states.
Industrial	IL, CA, TX, WI, MI, NJ	All other states except AK, DE, HI, KY, ME, NH, NM, OR, SD, UT, VT, WY.
Silica stone 6/	AR and WI	
Silver 1/	NV, AZ, ID, UT, AK, MT	CA, CO, IL, MI, MO, NM, NY, OR, SC, SD, TN, WA, WI.
Sodium compounds:		
Soda ash	WY and CA	
Sodium sulfate (natural)	TX and CA	
Staurolite	FL	

See footnotes at end of table.

TABLE 3 -- Continued
NONFUEL MINERALS PRODUCED IN THE UNITED STATES, BY COMMODITY AND STATES IN 1994

(Based on quantity unless otherwise noted)

Mineral	Principal States	Other States
Stone:		
Crushed	PA, IL, NC, FL, GA, MO	All other states except DE.
Dimension	IN, GA, WI, VT, TX, NC	All other states except AK, DE, FL, HI, KY, LA, MS, NE, NV, NJ, ND, OR, RI, WY.
Sulfur (Frasch)	LA and TX	
Talc and pyrophyllite	MT, NY, TX, VT, MC, CA	VA and OR.
Tin	(7/)	
Titanium concentrates	FL and CA	
Tripoli	IL, OK, AR, PA	
Tungsten 1/	CA	
Vanadium 1/	ID	
Vermiculite (crude)	SC and VA	
Wollastonite	NY	
Zeolites	TX, OR, NV, NJ, AZ, CA	ID.
Zinc 1/	AK, TN, NY, MO, MT, CO	IL, ID, OR.
Zircon concentrates	FL	

e/ Estimated.

1/ Content of ores, etc.

2/ Principal producing States based on value.

3/ Placer canvassing discontinued beginning 1994. May include some placer data from other sources.

4/ Includes byproduct material.

5/ Canvassing discontinued.

6/ Formerly identified as "Abrasives." Includes grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

7/ No production.

TABLE 3
NONFUEL MINERALS PRODUCED IN THE UNITED STATES, BY COMMODITY AND STATES IN 1994

(Based on quantity unless otherwise noted)

Mineral	Principal States	Other States
Antimony 1/	ID	
Asbestos	CA and VT	
Barite	GA, NV, MO, MT,TN, IL	
Bauxite	AL and GA	
Beryllium concentrate	UT	
Boron minerals	CA	
Bromine e/	AR	
Brucite	NV	
Cement:		
Masonry	FL, IN, AL, MD, SC, PA	All other states except AK, CT, DE, LA, MA, MN, MS, NV, NH, NJ, NC, ND, OR, RI, VT, WI, WY.
Portland	CA, TX, MI, PA, MO, AL	All other states except AK, CT, DE, LA, MA, MN, NH, NJ, NC, ND, RI, VT, WI.
Clays	GA, WY, FL, CA, MS, TN	All other states except AK, DE, HI, ID, RI, VT, WI.
Copper 1/	AZ, UT, NM, MT, MI, WI	ID, IL, MO, NV, OR, and TN.
Diatomite	CA, NV, WA, OR	
Emery	OR	
Feldspar	NC, CA, VA, GA, OK, ID	SD
Fluorspar	IL	
Garnet (abrasive)	ID and NY	
Gemstones (natural) 2/	TN, AR, AL, KY, AZ, MT	All other states.
Gold 1/ 3/	NV, CA, UT, SD, MT, WA	AK, AZ, CO, ID, NM, OR, SC, WI.
Greensand	NJ	
Gypsum (crude)	OK, MI, IA, TX, NV,IN	AR, AZ, CA, CO, IN, KS, LA, NM, NY, OH, UT, VA, WY.
Helium (crude and Grade-A)	KS, WY, TX, UT, CO	
Iodine	OK	
Iron ore (usable) 4/	MN, MI, MO, UT, TX, SD	CA, MI, NM
Iron oxide pigments (crude)	MO, GA, MI, VA, AZ	
Kyanite	VA	
Lead 1/	MO, AK, ID, MT, CO, NY	IL and TN.
Lime	OH, MO, PA, AL, KY, TX	All other states except AK, CT, DE, FL, GA, HI, KS, ME, MD, MS, NH, NJ, NM, NY, NC, RI, SC, VT.
Lithium minerals	NC and NV	
Magnesite	NV	
Magnesium compounds	MI, DE, FL, CA, UT, TX	
Magnesium metal	TX, WA, UT	
Manganiferous ore	SC	
Mercury	NV, UT, CA	
Mica (scrap)	NC, GA, NM, SC, SD	
Molybdenum	AZ, CO, UT, MT, ID, NM	
Nickel ore	OR	
Olivine	WA and NC	
Palladium metal	MT	
Peat	MI, FL, MN, IL, ME, NC	CO, IA, ME, MA, MT, NJ, NY, ND, OH, PA, SC, WA, WV, WI.
Perlite	NM, AZ, CA, NV	
Phosphate rock	FL, NC, ID, UT	
Platinum metal	MT	
Potash	NM, UT, CA, MI	
Pumice	CA, OR, AZ, NM, KS, ID	
Pyrites (ore and concentrate)	(5/)	
Rare-earth metal concentrates	CA and FL	
Salt	NY, OH, LA, KS, MI, TX	AL, AZ, CA, NV, NM, OK, UT, WV.
Sand and gravel:		
Construction	CA, TX, OH, AZ, WA, MI	All other states.
Industrial	IL, CA, TX, WI, MI, NJ	All other states except AK, DE, HI, KY, ME, NH, NM, OR, SD, UT, VT, WY.
Silica stone 6/	AR and WI	
Silver 1/	NV, AZ, ID, UT, AK, MT	CA, CO, IL, MI, MO, NM, NY, OR, SC, SD, TN, WA, WI.
Sodium compounds:		
Soda ash	WY and CA	
Sodium sulfate (natural)	TX and CA	
Staurolite	FL	

See footnotes at end of table.

TABLE 3 -- Continued
NONFUEL MINERALS PRODUCED IN THE UNITED STATES, BY COMMODITY AND STATES IN 1994

(Based on quantity unless otherwise noted)

Mineral	Principal States	Other States
Stone:		
Crushed	PA, IL, NC, FL, GA, MO	All other states except DE.
Dimension	IN, GA, WI, VT, TX, NC	All other states except AK, DE, FL, HI, KY, LA, MS, NE, NV, NJ, ND, OR, RI, WY.
Sulfur (Frasch)	LA and TX	
Talc and pyrophyllite	MT, NY, TX, VT, MC, CA	VA and OR.
Tin	(7/)	
Titanium concentrates	FL and CA	
Tripoli	IL, OK, AR, PA	
Tungsten 1/	CA	
Vanadium 1/	ID	
Vermiculite (crude)	SC and VA	
Wollastonite	NY	
Zeolites	TX, OR, NV, NJ, AZ, CA	ID.
Zinc 1/	AK, TN, NY, MO, MT, CO	IL, ID, OR.
Zircon concentrates	FL	

e/ Estimated.

1/ Content of ores, etc.

2/ Principal producing States based on value.

3/ Placer canvassing discontinued beginning 1994. May include some placer data from other sources.

4/ Includes byproduct material.

5/ Canvassing discontinued.

6/ Formerly identified as "Abrasives." Includes grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

7/ No production.

TABLE 4
VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1994 1/

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$626,000	18	1.78	Cement (portland), stone (crushed and broken), lime, sand and gravel (construction), clays, cement (masonry).
Alaska	519,000	23	1.48	Zinc, gold, sand and gravel (construction), lead, stone (crushed and broken), silver.
Arizona	3,280,000	1	9.33	Copper, sand and gravel (construction), cement (portland), molybdenum, lime, silver.
Arkansas	405,000	30	1.15	Bromine, stone (crushed and broken), sand and gravel (construction), cement (portland), sand and gravel (industrial), lime.
California	2,580,000	3	7.35	Cement (portland), sand and gravel (construction), boron, gold, stone (crushed and broken), diatomite.
Colorado	410,000	29	1.17	Sand and gravel (construction), cement (portland), molybdenum, gold, stone (crushed and broken), zinc.
Connecticut	81,800	44	0.23	Stone (crushed and broken), sand and gravel (construction), stone (dimension), sand and gravel (industrial), clays, gemstones.
Delaware 2/	8,680	50	0.03	Sand and gravel (construction), magnesium compounds, gemstones.
Florida	1,370,000	8	3.90	Phosphate rock, stone (crushed and broken), cement (portland), sand and gravel (construction), clays, titanium concentrates.
Georgia	1,550,000	4	4.41	Clays, stone (crushed and broken), cement (portland), sand and gravel (construction), stone (dimension), cement (masonry).
Hawaii 2/	116,000	43	0.33	Stone (crushed and broken), cement (portland), sand and gravel (construction), cement (masonry), gemstones.
Idaho	346,000	32	0.98	Phosphate rock, sand and gravel (construction), gold, molybdenum, silver, stone (crushed and broken).
Illinois	823,000	16	2.34	Stone (crushed and broken), cement (portland), sand and gravel (construction), sand and gravel (industrial), lime, clays.
Indiana	555,000	21	1.58	Stone (crushed and broken), cement (portland), sand and gravel (construction), lime, cement (masonry), stone (dimension).
Iowa	451,000	26	1.28	Stone (crushed and broken), cement (portland), sand and gravel (construction), gypsum, lime, cement (masonry).
Kansas	497,000	25	1.41	Salt, helium (Grade-A), stone (crushed abd broken), cement (portland), helium (crude), sand and gravel (construction).
Kentucky	428,000	28	1.22	Stone (crushed and broken), lime, cement (portland), sand and gravel (construction), clays, cement (masonry).
Louisiana	354,000	31	1.01	Salt, sulfur (Frasch), sand and gravel (construction), stone (crushed and broken), sand and gravel (industrial), lime.
Maine	61,000	45	0.17	Sand and gravel (construction), cement (portland), stone (crushed and broken), cement (masonry), peat, stone (dimension).
Maryland	340,000	33	0.97	Stone (crushed and broken), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension), clays.
Massachusetts	178,000	40	0.51	Stone (crushed and broken), sand and gravel (construction), lime, stone (dimension), clays, peats.
Michigan	1,430,000	7	4.06	Iron ore (usable), cement (portland), sand and gravel (construction), magnesium compounds, stone (crushed and broken), copper.
Minnesota	1,340,000	9	3.82	Iron ore (usable), sand and gravel (construction), stone (crushed and broken), sand and gravel (industrial), stone (dimension), lime.
Mississippi	135,000	42	0.38	Sand and gravel (construction), clays, cement (portland), stone (crushed and broken), sand and gravel (industrial), gemstones.
Missouri	1,090,000	10	3.09	Stone (crushed and broken), cement (portland), lead, lime, zinc, sand and gravel (construction).
Montana	543,000	22	1.54	Gold, copper, cement (portland), molybdenum, palladium metal, sand and gravel (construction).
Nebraska	146,000	41	0.42	Cement (portland), sand and gravel (construction), stone (crushed and broken), lime, clays, cement (masonry).
Nevada	3,070,000	2	8.73	Gold, silver, sand and gravel (construction), diatomite, lime, cement (portland).
New Hampshire 2/	46,400	47	0.13	Sand and gravel (construction), stone (dimension), stone (crushed and broken), gemstones, clays.
New Jersey	289,000	36	0.82	Stone (crushed and broken), sand and gravel (construction), sand and gravel (industrial), greensand marl, clays, peat.
New Mexico	929,000	12	2.64	Copper, potash, sand and gravel (construction), cement (portland), stone (crushed and broken), perlite.
New York	892,000	13	2.54	Stone (crushed and broken), salt, cement (portland), sand and gravel (construction), zinc, wollastonite.
North Carolina	708,000	17	2.01	Stone (crushed and broken), phosphate rock, lithium minerals, sand and gravel (construction), sand and gravel (industrial), feldspar.
North Dakota	25,300	49	0.07	Sand and gravel (construction), lime, clays, sand and gravel (industrial), gemstones, peat.
Ohio	880,000	15	2.50	Stone (crushed and broken), sand and gravel (construction), salt, lime, cement (portland), sand and gravel (industrial).
Oklahoma	340,000	34	0.97	Stone (crushed and broken), cement (portland), sand and gravel (construction), sand and gravel (industrial), gypsum, iodine.
Oregon	243,000	38	0.69	Stone (crushed and broken), sand and gravel (construction), cement (portland), lime, diatomite, pumice.
Pennsylvania	1,010,000	11	2.86	Stone (crushed and broken), cement (portland), lime, sand and gravel (construction), cement (masonry), sand and gravel (industrial).
Rhode Island 2/	26,300	48	0.08	Sand and gravel (construction), stone (crushed and broken), sand and gravel (industrial), gemstones.
South Carolina	433,000	27	1.23	Cement (portland), stone (crushed and broken), gold, clays, sand and gravel (construction), cement (masonry).
South Dakota	324,000	35	0.92	Gold, cement (portland), stone (crushed and broken), sand and gravel (construction), stone (dimension), lime.
Tennessee	602,000	19	1.71	Stone (crushed and broken), zinc, cement (portland), sand and gravel (construction), clays, gemstones.
Texas	1,530,000	5	4.36	Cement (portland), stone (crushed and gravel), sand and gravel (construction), magnesium metal, lime, salt.
Utah	1,520,000	6	4.33	Copper, gold, magnesium metal, sand and gravel (construction), cement (portland), salt.

See footnotes at end of table.

TABLE 4 -- Continued

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 1994 1/

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Vermont 2/	48,600	46	0.14	Stone (crushed and broken), sand and gravel (construction), stone (dimension), talc and pyrophyllite, asbestos, gemstones.
Virginia	502,000	24	1.43	Stone (crushed and broken), cement (portland), lime, sand and gravel (construction), clays, kyanite.
Washington	571,000	20	1.63	Sand and gravel (construction), magnesium metal, gold, stone (crushed and gravel), cement (portland), lime.
West Virginia	181,000	39	0.52	Stone (crushed and broken), cement (portland), sand and gravel (industrial), salt, lime, cement (masonry).
Wisconsin 2/	283,000	37	0.80	Stone (crushed and broken), copper, sand and gravel (construction), sand and gravel (industrial), lime, gold.
Wyoming	880,000	14	2.50	Soda ash, clays, helium (Grade-A), cement (portland), stone (crushed and broken), sand and gravel (construction).
Undistributed	155,000	--	0.44	
Total	35,200,000	XX	100.00	

XX Not applicable.

1/ Data rounded by the U.S. Bureau of Mines to three siginificant digits; may not add to totals shown.

2/ Partial total, excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed" figure.

TABLE 5
VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE MILE IN 1994, BY STATE 1/

State	Area (square miles)	Population (thousands)	Total value (thousands)	Per capita		Per square mile	
				Dollars	Rank	Dollars	Rank
Alabama	51,700	4,220	$626,000	148	17	12,100	25
Alaska	591,000	606	519,000	856	3	877	49
Arizona	114,000	4,080	3,280,000	804	4	28,800	3
Arkansas	53,200	2,450	405,000	165	14	7,620	31
California	159,000	31,400	2,580,000	82	33	16,300	16
Colorado	104,000	3,660	410,000	112	20	3,940	43
Connecticut	5,020	3,280	81,800	25	49	16,300	15
Delaware	2,040	706	8,680 2/	12	50	4,250	40
Florida	58,700	14,000	1,370,000	98	26	23,400	7
Georgia	58,900	7,060	1,550,000	220	11	26,300	5
Hawaii	6,470	1,180	116,000 2/	98	27	17,900	14
Idaho	83,600	1,130	346,000	305	9	4,140	42
Illinois	56,300	11,800	823,000	70	38	14,600	20
Indiana	36,200	5,750	555,000	97	28	15,300	19
Iowa	56,300	2,830	451,000	160	15	8,020	29
Kansas	82,300	2,550	497,000	194	13	6,040	34
Kentucky	40,400	3,830	428,000	112	21	10,600	26
Louisiana	47,800	4,320	354,000	82	34	7,410	33
Maine	33,300	1,240	61,000	49	42	1,830	48
Maryland	10,500	5,010	340,000	68	39	32,500	2
Massachusetts	8,280	6,040	178,000	29	47	21,400	10
Michigan	58,500	9,500	1,430,000	150	16	24,400	6
Minnesota	84,400	4,570	1,340,000	294	10	15,900	17
Mississippi	47,700	2,670	135,000	51	41	2,830	45
Missouri	69,700	5,280	1,090,000	206	12	15,600	18
Montana	147,000	856	543,000	634	6	3,690	44
Nebraska	77,400	1,620	146,000	90	29	1,890	47
Nevada	111,000	1,460	3,070,000	2,110	1	27,800	4
New Hampshire	9,280	1,140	46,400 2/	41	44	5,000	38
New Jersey	7,790	7,900	289,000	37	46	37,100	1
New Mexico	122,000	1,650	929,000	562	7	7,640	30
New York	49,100	18,200	892,000	49	43	18,200	12
North Carolina	52,700	7,070	708,000	100	24	13,400	23
North Dakota	70,700	638	25,300	40	45	358	50
Ohio	41,300	11,100	880,000	79	35	21,300	11
Oklahoma	70,000	3,260	340,000	104	23	4,860	39
Oregon	97,100	3,090	243,000	79	36	2,500	46
Pennsylvania	45,300	12,100	1,010,000	83	31	22,200	8
Rhode Island	1,210	997	26,300 2/	26	48	21,700	9
South Carolina	31,100	3,660	433,000	118	18	13,900	22
South Dakota	77,100	721	324,000	449	8	4,200	41
Tennessee	42,100	5,180	602,000	116	19	14,300	21
Texas	267,000	18,400	1,530,000	83	32	5,750	35
Utah	84,900	1,910	1,520,000	799	5	17,900	13
Vermont	9,610	580	48,600 2/	84	30	5,060	36
Virginia	40,800	6,550	502,000	77	37	12,300	24
Washington	68,100	5,340	571,000	107	22	8,380	28
West Virginia	24,200	1,820	181,000	99	25	7,470	32
Wisconsin	56,200	5,080	283,000 2/	56	40	5,040	37
Wyoming	97,800	476	880,000	1,850	2	9,000	27
Undistributed	XX	XX	155,000	XX	XX	XX	XX
Total or average	3,620,000 3/	260,000 3/	35,200,000	135	XX	9,710	XX

XX Not applicable.

1/ Data rounded by the U.S. Bureau of Mines to three siginificant digits; may not add to totals shown.

2/ Partial total, excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed" figure.

3/ Excludes Washington, DC (which has no mineral production), with an area of 69 square miles and a population of 570,000.

Sources: U.S. Bureau of Mines and Bureau of the Census.

TABLE 6
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ALABAMA							
Cement:							
Masonry	thousand metric tons	193	$11,100	277	$21,900	312	$28,900
Portland	do.	3,720	181,000	3,750	191,000	3,980	248,000
Clays 3/	do.	2,380	20,900	2,490	23,200	2,280	25,400
Lime	do.	1,450	82,600	1,630	89,500	1,660	88,300
Sand and gravel:							
Construction	do.	11,200	42,000	10,300 e/	39,100 e/	12,500	47,600
Industrial	do.	605	6,770	559	6,800	610	7,160
Stone (crushed)	do.	25,900 e/ 4/	176,000 e/ 4/	28,900	176,000	32,500	164,000
Combined value of bauxite, clays [bentonite, kaolin (1992)], gemstones, salt, and stone (crushed dolomite and granite (1992), dimension (1992-93), dimension (limestone,marble,and sandstone)]		XX	22,900	XX	14,900	XX	16,500
Total		XX	543,000	XX	562,000	XX	626,000
ALASKA							
Gemstones		NA	10	NA	10	NA	10
Gold 5/	kilograms	5,000	55,500	2,780	32,200	5,740 6/	71,100 6/
Sand and gravel (construction)	thousand metric tons	13,600	43,300	13,100 e/	42,600 e/	15,700	56,200
Stone (crushed)	do.	2,720 e/ 4/	13,400 e/ 4/	2,430	11,300 5/	3,870	24,100
Combined value of lead, silver, stone [crushed sandstone (1992-93)], tin (1993-94), and zinc		XX	414,000	XX	291,000	XX	367,000
Total		XX	526,000	XX	378,000	XX	519,000
ARIZONA							
Clays 3/	thousand metric tons	102	463	97	451	98	452
Copper 5/	metric tons	1,150,000	2,730,000	1,160,000	2,340,000	1,120,000	2,750,000
Gemstones		NA	5,420	NA	5,630	NA	3,550
Gold 5/	kilograms	6,660	73,800	2,710	31,500	1,980 6/	24,500 6/
Iron oxide pigments (crude)	metric tons	77	62	77	62	77	62
Sand and gravel (construction)	thousand metric tons	30,700	124,000	35,000 e/	138,000 e/	34,800	166,000
Silver 5/	metric tons	165	20,900	200	27,700	192	32,600
Stone (crushed)	thousand metric tons	4,990 e/	26,300 e/	6,430	36,800	4,970	25,000
Combined value of cement, clays (bentonite), gypsum (crude), lead (1992), lime, molybdenum, perlite, pumice, pyrites 7/ (1992-93), salt, sand and gravel (industrial), stone [dimension (1992-93), dimension sandstone (1994)], and tin (1992)		XX	184,000	XX	196,000	XX	274,000
Total		XX	3,160,000	XX	2,780,000	XX	3,280,000
ARKANSAS							
Bromine e/	metric tons	171,000	170,000	177,000	123,000	W	W
Clays 3/	thousand metric tons	837	2,970	1,030	2,360	883	2,440
Gemstones		NA	1,490	NA	5,530	NA	3,950
Sand and gravel:							
Construction	thousand metric tons	9,900	39,600	10,100 e/	40,900 e/	10,600	42,500
Industrial	do.	806	10,500	642	7,600	684	8,230
Silica stone 8/	metric tons	W	W	W	W	469	3,910
Stone (crushed) 4/	do.	22,900 e/	119,000 e/	21,700	103,000	20,800	122,000
Combined value of cement, clays (fire, kaolin), gypsum (crude), lime, stone [crushed dolomite and quartzite (1993), crushed dolomite and traprock (1992), crushed limestone and traprock (1994), dimension (1992-93), dimension limestone, marble, and sandstone (1994)], talc and pyrophyllite (1993), tripoli, and values indicated by symbol W		XX	60,400	XX	65,100	XX	223,000
Total		XX	404,000	XX	347,000	XX	405,000

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
CALIFORNIA							
Asbestos	metric tons	11,000	$4,450	10,000	$4,430	8,990	$4,200
Boron minerals (B2O3)	thousand metric tons	554	339,000	574	373,000	550	443,000
Cement:							
Masonry	do.	W	W	W	W	99	6,830
Portland	do.	7,290	428,000	8,510	468,000	9,640	539,000
Clays 3/	do.	1,910	26,200	1,930 r/	26,300 r/	1,570	20,600
Gemstones		NA	9,920	NA	673	NA	1,710
Gold 5/	kilograms	33,300	370,000	35,800	415,000	30,100 6/	373,000 6/
Lime	thousand metric tons	254	18,100	193	14,800	203	16,900
Mercury	metric tons	(9/)	(9/)	W	W	W	W
Rare-earth metal concentrates	do.	20,700	W	17,800	W	20,700	W
Sand and gravel:							
Construction	thousand metric tons	102,000	522,000	96,300 e/	476,000 e/	96,300	523,000
Industrial	do.	1,920	42,500	1,800	41,700	1,740	39,400
Silver 5/	metric tons	18	2,260	14	2,000	11	1,910
Stone:							
Crushed	thousand metric tons	37,000 e/	198,000 e/	38,200	250,000	41,100	258,000
Dimension	metric tons	21,100 e/	4,150 e/	29,100	6,300	11,100	4,030
Combined value of calcium chloride 10/ (1992), cement (masonry), clays [fuller's earth, kaolin (1994)], diatomite, feldspar, gypsum (crude), iron ore (usable), magnesium compounds, molybdenum (1992), perlite, potash, pumice, salt, soda ash, sodium sulfate (natural), stone [dimension limestone, sandstone, and slate (1994)], talc and pyrophyllite, titanium (ilmenite), tungsten, and values indicated by symbol W		XX	403,000	XX	362,000	XX	351,000
Total		XX	2,370,000	XX	2,440,000 r/	XX	2,580,000
COLORADO							
Clays	thousand metric tons	242 3/	1,800 3/	281	2,160	291	2,320
Gemstones		NA	225	NA	258	NA	267
Gold 5/	kilograms	3,760	41,700	W	W	4,420 6/	54,700 6/
Peat	thousand metric tons	W	333	W	W	W	W
Sand and gravel (construction)	do.	26,700	105,000	29,000 e/	118,000 e/	29,000	109,000
Stone:							
Crushed	do.	10,900 e/	60,400 e/	10,300	62,000	8,600	53,600
Dimension	metric tons	5,850 e/	252 e/	4,320	1,370	3,630 4/	51 4/
Combined value of cement, clays [fire (1992)], copper (1992-93), gypsum (crude), helium (Grade-A), lead, lime, molybdenum, perlite (1992-93), sand and gravel (industrial), silver, stone stone [dimension marble (1994)], zinc, and values indicated by symbol W		XX	175,000	XX	216,000	XX	191,000
Total		XX	385,000	XX	399,000	XX	410,000
CONNECTICUT							
Gemstones		NA	5	NA	5	NA	5
Sand and gravel (construction)	thousand metric tons	5,470	30,100	6,400 e/	34,900 e/	5,420	28,000
Stone (crushed)	do.	5,350 e/ 4/	54,500 e/ 4/	4,600 4/	39,500 4/	5,710	51,000
Combined value of clays (common), sand and gravel (industrial), and stone [crushed dolomite and miscellaneous (1992-93), dimension (1992-93), dimension grantie and quartzite (1994)]		XX	13,500	XX	16,200	XX	2,670
Total		XX	98,100	XX	90,700	XX	81,800
DELAWARE							
Gemstones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand metric tons	2,260	8,570	2,500 e/	10,300 e/	2,580	8,680
Total 11/		XX	8,580	XX	10,300	XX	8,680

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
FLORIDA							
Cement:							
Masonry	thousand metric tons	310	$22,400	351	$27,300	400	$34,600
Portland	do.	2,900	162,000	4,190	211,000	3,370	228,000
Clays 3/	do.	367	37,200	407	52,700	430	55,000
Gemstones		NA	1	NA	W	NA	W
Peat	thousand metric tons	191	3,160	219	3,780	206	3,230
Sand and gravel:							
Construction	do.	21,100	66,100	22,800 e/	73,100 e/	16,600	60,700
Industrial	do.	433	5,170	504	5,910	540	6,120
Stone (crushed) 4/	do.	53,800 e/	267,000 e/	64,900	313,000	67,000	343,000
Combined value of clays (common), magnesium compounds, phosphate rock, rare-earth metal metal concentrates, staurolite, stone [crushed dolomite and limestone (1993), crushed marl (1992)], titanium concentrates (ilmenite and rutile), zircon concentrates, and values indicated by symbol W		XX	877,000	XX	624,000	XX	639,000
Total		XX	1,440,000	XX	1,310,000	XX	1,370,000
GEORGIA							
Clays 3/	thousand metric tons	8,960	971,000	9,660 r/	994,000 r/	9,960	1,060,000
Gem stones		NA	645	NA	51	NA	51
Sand and gravel:							
Construction	thousand metric tons	4,410	15,600	4,600 e/	16,600 e/	5,520	19,800
Industrial	do.	533	8,780	491	7,940	440	7,040
Stone:							
Crushed	do.	39,900 e/ 4/	244,000 e/ 4/	49,400	292,000	54,600	331,000
Dimension	metric tons	144,000 e/ 4/	13,100 e/ 4/	176,000 4/	18,700 4/	200,000	19,100
Combined value of barite, bauxite, cement, clays (fire), feldspar, iron oxide pigments (crude), mica (scrap), and stone [crushed marl, marble, and miscellaneous (1992), dimension marble (1992-93), dimension marble and miscellaneous (1994)]		XX	93,000	XX	101,000	XX	116,000
Total		XX	1,350,000	XX	1,430,000 r/	XX	1,550,000
HAWAII							
Cement:							
Masonry	thousand metric tons	7	1,420	7	880	6	395
Portland	do.	520	53,900	451	48,300	404	28,300
Sand and gravel (construction)	do.	W	W	W	W	521	4,740
Stone (crushed)	do.	9,530 e/ 4/	93,500 e/ 4/	8,460	81,400	8,170	82,300
Combined value of other industrial minerals		XX	(12/)	XX	8,140	XX	(12/)
Total		XX	149,000 11/	XX	139,000	XX	116,000 11/
IDAHO							
Gemstones		NA	390	NA	566	NA	287
Gold 5/	kilograms	4,040	44,800	W	W	W	W
Molybdenum	metric tons	W	W	--	--	W	W
Phosphate rock	thousand metric tons	5,210	84,000	4,360	78,400	W	W
Pumice	metric tons	55,500	401	43,400	327	W	W
Sand and gravel:							
Construction	thousand metric tons	13,500	40,700	13,600 e/	44,900 e/	14,500	46,300
Industrial	do.	728	9,210	W	W	W	W
Silver 5/	metric tons	254	32,100	190	26,200	W	W
Stone (crushed)	thousand metric tons	3,630 e/	19,200 e/	4,600	20,800	4,160	20,300
Combined value of antimony, cement, clays [common (1992-93)], copper, feldspar, garnet (abrasive), lead, lime, perlite (1992), stone (dimension), vanadium ore, zinc, and values indicated by symbol W		XX	79,000	XX	103,000	XX	279,000
Total		XX	310,000	XX	274,000	XX	346,000

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ILLINOIS							
Cement (portland)	thousand metric tons	2,590	$119,000	2,430	$123,000	2,590	$151,000
Clays 3/	do.	535	2,360	477	1,090	494	1,170
Gemstones		NA	715	NA	328	NA	376
Sand and gravel:							
Construction	thousand metric tons	32,400	124,000	34,500 e/	137,000 e/	37,900	150,000
Industrial	do.	4,240	57,500	4,220	61,700	4,420	65,700
Stone (crushed) 4/	do.	66,000 e/	323,000 e/	61,500	315,000	62,600	353,000
Combined value of barite, cement (masonry (1992, 1994)], clays (fuller's earth), copper, fluorspar, lead, lime, peat, silver, stone [crushed sandstone (1993), crushed sandstone and limestone (1992), crushed miscellaneous (1994), dimension (1992-93), dimension dolomite (1994)], zinc, and values indicated by symbol W		XX	108,000	XX	95,900	XX	102,000
Total		XX	734,000	XX	734,000	XX	823,000
INDIANA							
Cement:							
Masonry	thousand metric tons	337	24,800	W	W	W	W
Portland	do.	2,240	111,000	2,060	109,000	2,290	132,000
Clays 3/	do.	842	3,020	600	2,540	774	2,540
Gemstones		NA	720	NA	47	NA	29
Peat	thousand metric tons	25	512	24	W	23	W
Sand and gravel:							
Construction	do.	26,200	95,900	27,000 e/	103,000 e/	28,100	108,000
Industrial	do.	107	1,280	W	W	W	W
Stone:							
Crushed	do.	39,000 e/	178,000 e/	36,900	166,000	45,900	211,000
Dimension	metric tons	173,000 e/	26,800 e/	156,000 4/	22,900 4/	173,000	25,800
Combined value of clays (ball), gypsum (crude), lime, stone [dimension sandstone (1993)], and values indicated by symbol W		XX	35,100	XX	69,100 r/	XX	75,400
Total		XX	477,000	XX	472,000 r/	XX	555,000
IOWA							
Cement:							
Masonry	thousand metric tons	45	4,120	W	W	W	W
Portland	do.	2,560	116,000	2,300	136,000	2,390	153,000
Clays	do.	389	1,610	358	1,670	384	1,520
Gemstones		NA	1,610	NA	46	NA	50
Gypsum (crude)	thousand metric tons	1,990	11,600	1,990	12,300	2,210	12,700
Peat	do.	W	W	W	W	5	W
Sand and gravel (construction)	do.	15,300	58,400	16,600 e/	64,700 e/	15,300	58,200
Stone (crushed)	do.	34,500 e/ 4/	186,000 e/ 4/	30,500	169,000	36,600	211,000
Combined value of lime, sand and gravel (industrial), stone crushed dolomite and limestone (1992), crushed dolomite and miscellaneous (1994), dimension], and values indicated by symbol W		XX	11,100	XX	13,900	XX	15,400
Total		XX	391,000	XX	398,000	XX	451,000
KANSAS							
Cement:							
Masonry	thousand metric tons	31	1,910	35	2,410	24	2,090
Portland	do.	1,550	79,500	1,380	73,900	1,640	101,000
Clays	do.	544	3,920	513 3/	1,970 3/	556 3/	2,150 3/
Helium:							
Crude	million cubic meters	W	W	23	20,400	32	31,400
Grade-A	do.	W	W	52	104,000	53	105,000
Salt	thousand metric tons	1,850 13/	98,600 13/	2,320 13/	103,000 13/	2,660	108,000
Sand and gravel (construction)	do.	10,900	27,300	11,900 e/	30,700 e/	11,200	29,600

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral	1992		1993		1994	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
KANSAS -- Continued						
Stone:						
Crushed thousand metric tons	15,300 e/ 4/	69,600 e/ 4/	18,800 4/	90,700 4/	21,500	103,000
Dimension metric tons	W	W	24,700 4/	2,540 4/	23,700 4/	1,730 4/
Combined value of clays [fuller's earth (1993-94)], gemstones, gypsum (crude), pumice, salt [brine (1992-93)], sand and gravel (industrial), stone [crushed quartzite (1992), crushed sandstone (1993), dimension (1992), dimension sandstone (1993-94)], and values indicated by symbol W	XX	124,000	XX	12,600	XX	11,900
Total	XX	405,000	XX	442,000	XX	497,000
KENTUCKY						
Clays 3/ thousand metric tons	760	3,780	768	3,060	820	3,460
Sand and gravel (construction) do.	6,710	24,400	7,700 e/	29,900 e/	9,140	32,200
Stone (crushed) do.	53,300 e/	251,000 e/	49,000 4/	226,000 4/	56,300	259,000
Combined value of cement, clays (ball), gemstones, lime, and stone [crushed sandstone (1993)]	XX	121,000	XX	128,000	XX	134,000
Total	XX	401,000	XX	388,000	XX	428,000
LOUISIANA						
Clays thousand metric tons	384	3,590	375	496	371	3,280
Gemstones	NA	3,960	NA	141	NA	155
Salt thousand metric tons	12,100	112,000	12,400	115,000	13,500	140,000
Sand and gravel:						
Construction do.	11,500	48,700	11,900 e/	51,500 e/	12,300	49,600
Industrial do.	471	9,270	465	9,360	454	9,320
Stone (crushed) do.	W	W	W	W	707 4/	7,710 4/
Sulfur (Frasch) do.	1,110	W	740	W	W	W
Combined value of gypsum (crude), lime, stone [crushed limestone, shell, and miscellaneous (1993), crushed shell and miscellaneous (1992,1994)], and values indicated by symbol W	XX	131,000	XX	54,600	XX	144,000
Total	XX	309,000	XX	232,000	XX	354,000
MAINE						
Gemstones	NA	108	NA	9,690	NA	235
Sand and gravel (construction) thousand metric tons	6,080	26,900	4,400 e/	18,900 e/	5,890	24,400
Stone (crushed) do.	1,720 e/	11,400 e/	1,830	10,400	2,740	15,500
Combined value of cement, clays (common), peat, and stone (dimension)	XX	17,500	XX	21,200	XX	20,900
Total	XX	55,900	XX	60,100	XX	61,000
MARYLAND						
Cement (portland) thousand metric tons	1,510	84,200	1,630	81,600	1,710	90,700
Clays do.	227	980	294	705	293	946
Gemstones	NA	1	NA	1	NA	1
Sand and gravel (construction) thousand metric tons	10,900	69,300	11,200 e/	72,200 e/	8,920	61,200
Stone:						
Crushed do.	21,600 e/	180,000 e/	23,100	152,000	24,100 4/	162,000 4/
Dimension metric tons	10,300 e/	1,020 e/	19,300	2,020	18,800 4/	1,550 4/
Combined value of other industrial minerals	XX	3,470	XX	4,680	XX	24,000
Total	XX	339,000	XX	314,000	XX	340,000
MASSACHUSETTS						
Gemstones	NA	1	NA	W	NA	W
Sand and gravel:						
Construction thousand metric tons	10,900	48,700	10,800 e/	51,300 e/	12,300	60,000
Industrial do.	8	151	2	42	W	W
Stone:						
Crushed do.	9,430 e/	77,200 e/	9,460 4/	76,300 4/	10,500	97,300
Dimension metric tons	59,700 e/	9,290 e/	153,000	21,300	57,300	9,600

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MASSACHUSETTS -- Continued							
Combined value of clays (common), lime, peat, and stone [crushed dolomite and miscellaneous (1993)], and values indicated by symbol W		XX	$12,100	XX	$11,300	XX	$10,600
Total		XX	147,000	XX	160,000	XX	178,000
MICHIGAN							
Cement:							
Masonry	thousand metric tons	212	20,400	216	17,400	235	17,700
Portland	do.	5,000	262,000	5,120	313,000	5,160	331,000
Clays	do.	1,260	4,350	1,230	4,850	1,150	3,370
Gemstones		NA	1	NA	1	NA	2
Gypsum (crude)		1,610	13,900	1,690	14,200	1,790	15,300
Iron ore (usable)	thousand metric tons	12,900	W	12,900	W	13,800	W
Lime	do.	577	31,300	617 r/	32,100 r/	637	33,000
Peat	do.	181	5,890	186	6,110	156	5,090
Sand and gravel:							
Construction	do.	43,500	143,000	45,000 e/	158,000 e/	48,800	160,000
Industrial	do.	1,950	22,600	2,570	25,100	2,870	31,300
Stone:							
Crushed	do.	35,000 e/	126,000 e/	31,000	112,000	35,000	113,000
Dimension	do.	W	W	W	W	147 4/	35 4/
Combined value of calcium chloride [natural 4/ (1992)], copper, iron oxide pigments (crude), magnesium compounds, potash, salt, silver, stone (dimension), and values indicated by symbol W		XX	961,000	XX	823,000	XX	719,000
Total		XX	1,590,000	XX	1,510,000 r/	XX	1,430,000
MINNESOTA							
Gemstones		NA	686	NA	65	NA	26
Iron ore (usable)	thousand metric tons	42,300	1,180,000	42,500	1,130,000	43,300	1,160,000
Peat	do.	36	2,760	33	1,930	37	3,010
Sand and gravel (construction)	do.	34,100	98,700	30,500 e/	85,400 e/	29,500	90,000
Stone:							
Crushed	do.	9,530 e/	39,500 e/	9,420	37,700	10,900	47,100
Dimension	metric tons	32,800 e/	11,400 e/	33,500	11,800	16,900 4/	W
Combined value of clays (common, kaolin), lime, sand and gravel industrial), and values indicated by symbol W		XX	30,400	XX	35,500 r/	XX	44,900
Total		XX	1,360,000	XX	1,300,000 r/	XX	1,340,000
MISSISSIPPI							
Clays	thousand metric tons	1,120 3/	38,100 3/	1,100	34,300 r/	1,190 3/	40,500 3/
Gemstones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand metric tons	10,400	44,100	14,500 e/	57,300 e/	12,400	53,200
Stone (crushed)	do.	2,270 e/	10,400 e/	2,100	8,120	1,900	7,500
Combined value of other industrial minerals		XX	28,800	XX	(12/)	XX	33,900
Total		XX	121,000	XX	99,800 11/ r/	XX	135,000
MISSOURI							
Cement (portland)	thousand metric tons	4,290	196,000	4,060	201,000	4,730	265,000
Clays 3/	do.	1,200	8,330	1,180	7,740	1,250	7,910
Copper 4/	metric tons	10,800	25,500	6,980	14,100	7,720	18,900
Gemstones		NA	862	NA	46	NA	67
Iron ore (usable)	thousand metric tons	19	W	287	W	W	W
Lead 4/	metric tons	300,000	232,000	277,000	194,000	290,000	238,000
Sand and gravel:							
Construction	thousand metric tons	8,190	26,500	6,400 e/	19,800 e/	9,760	36,500
Industrial	do.	644	10,900	520	9,390	559	9,970
Silver 4/	metric tons	32	4,080	40	5,580	40	6,860
Stone (crushed)	thousand metric tons	47,400 e/	187,000 e/	53,400	239,000	68,900	330,000
Zinc 4/	metric tons	44,000	56,700	40,200	40,900	42,000	45,600

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
			MISSOURI -- Continued				
Combined value of barite, cement (masonry), clays (fuller's earth), iron oxide pigments (crude), lime, stone [dimension (1992), dimension (granite)], and values indicated by symbol W		XX	$148,000	XX	$123,000	XX	$128,000
Total		XX	897,000	XX	855,000	XX	1,090,000
			MONTANA				
Clays	thousand metric tons	35 3/	101 3/	W	W	28 3/	W
Gemstones		NA	674	NA	281	NA	3,400
Gold 5/	kilograms	14,000	155,000	14,300	166,000	12,600 6/	156,000 6/
Lead 5/	metric tons	W	W	W	W	9,940	8,140
Palladium	kilograms	6,470	18,100	6,500	25,300	6,440	29,400
Platinum	do.	1,840	21,100	1,800	21,400	1,960	25,300
Sand and gravel (construction)	thousand metric tons	10,100	31,400	10,000 e/	32,000 e/	7,360	28,800
Silver 5/	metric tons	197	25,000	127	17,600	71	12,000
Stone (crushed)	thousand metric tons	2,000 e/	6,200 e/	2,820	10,400	2,320	8,830
Talc and pyrophyllite	metric tons	408,000	16,200	350,000	11,900	W	W
Zinc 5/	do.	20,600	26,500	W	W	21,000	22,800
Combined value of barite, cement [masonry (1992,1994), portland], clays [bentonite, common (1993-94), fire (1993-94)], copper, iron ore [usable (1992-93)], lime, molybdenum, peat, phosphate rock (1992-93), sand and gravel (industrial), stone [dimension(1992), dimension miscellaneous (1993-94)], vermiculite (1992), and values indicated by symbol W		XX	239,000	XX	199,000	XX	249,000
Total		XX	539,000	XX	484,000	XX	543,000
			NEBRASKA				
Clays	thousand metric tons	183	879	192	932	206	867
Gemstones		NA	645	NA	W	NA	W
Lime	thousand metric tons	26	1,740	24	1,230	24	904
Sand and gravel (construction)	do.	12,000	38,100	12,900 e/	41,900 e/	15,000	49,200
Stone (crushed)	do.	5,350 e/	29,100 e/	6,760	38,900	6,890	41,600
Combined value of cement, sand and gravel (industrial), and values indicated by symbol W		XX	44,300	XX	43,200	XX	53,600
Total		XX	115,000	XX	126,000	XX	146,000
			NEVADA				
Barite	thousand metric tons	W	W	242	9,100	284	$5,020
Clays 3/	do.	51	7,720	16	3,430	7	2,860
Copper 5/	metric tons	W	W	W	W	6,450	15,800
Gemstones		NA	661	NA	660	NA	160
Gold 5/	kilograms	203,000	2,260,000	211,000	2,450,000	214,000 6/	2,650,000 6/
Mercury	metric tons	64	373	W	W	W	W
Sand and gravel:							
Construction	thousand metric tons	22,000	93,600	24,900 e/	108,000 e/	22,700	106,000
Industrial	do.	482	W	480	W	572	W
Silver 5/	metric tons	614	77,700	713	98,500	673	115,000
Stone (crushed)	thousand metric tons	1,090 e/	6,700 e/	1,070	12,500	2,310	20,600
Combined value of brucite, cement (portland), clays [fuller's earth (1993-94), kaolin],diatomite, fluorspar (1993), gypsum (crude), lime, lithium minerals, magnesite, perlite, salt, and values indicated by symbol W		XX	148,000	XX	144,000 r/	XX	153,000
Total		XX	2,590,000	XX	2,820,000 r/	XX	3,070,000
			NEW HAMPSHIRE				
Clays	thousand metric tons	W	W	3	16	3	16
Gemstones		NA	4	NA	9	NA	21
Sand and gravel (construction)	thousand metric tons	5,840	25,600	4,800 e/	20,700 e/	7,120	32,600

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEW HAMPSHIRE -- Continued							
Stone:							
Crushed	thousand metric tons	1,540 e/	$11,000 e/	1,390	$7,790	1,390 4/	$7,470 4/
Dimension	metric tons	34,200 e/	5,460 e/	53,100	8,670	35,300	6,300
Combined value of other industrial minerals and values indicated by symbol W		XX	(12/)	XX	--	XX	(12/)
Total		XX	42,000 11/	XX	37,200	XX	46,400 11/
NEW JERSEY							
Gemstones		NA	1	NA	1	NA	1
Sand and gravel:							
Construction	thousand metric tons	14,900	80,000	14,700 e/	80,100 e/	16,100	100,000
Industrial	do.	1,380	24,700	1,830	28,600	1,690	30,600
Stone (crushed)	do.	15,500 e/ 4/	126,000 e/ 4/	16,700 4/	138,000 4/	19,800	154,000
Combined value of clays [common, fire (1992-93)], greensand marl, peat, stone [crushed sandstone and miscellaneous (1992-93)], titanium concentrates (ilmenite and rutile,1992), and zircon concentrates (1992)		XX	9,720	XX	15,700	XX	4,460
Total		XX	240,000	XX	262,000	XX	289,000
NEW MEXICO							
Clays 3/	thousand metric tons	33	79	33	101	127	269
Copper 5/	metric tons	211,000	501,000	224,000	453,000	234,000	574,000
Gemstones		NA	34	NA	10	NA	14
Gold 5/	kilograms	W	W	995	11,600	W	W
Potash	thousand metric tons	1,440	257,000	1,310	216,000	2,450	218,000
Pumice	metric tons	W	W	W	W	129,000	1,050
Sand and gravel (construction)	thousand metric tons	10,200	46,200	11,100 e/	51,100 e/	10,400	47,400
Silver 5/	metric tons	W	W	22	3,090	22	3,750
Stone (crushed)	thousand metric tons	2,720 e/	14,400 e/	3,500 4/	18,400 4/	3,550 4/	20,000 4/
Combined value of cement, clays (fire), gypsum (crude), iron ore [usable (1993-94)], lead (1992), mica (scrap), molybdenum, perlite, salt, stone [crushed quartzite (1993), crushed quartzite and traprock (1994), dimension (1992-93), dimension granite, marble, and miscellaneous (1994], and values indicated by symbol W		XX	53,500	XX	51,200	XX	65,100
Total		XX	871,000	XX	804,000	XX	929,000
NEW YORK							
Cement:							
Masonry	thousand metric tons	W	W	75	5,420	82	6,020
Portland	do.	W	W	2,970	149,000	2,650	139,000
Clays	do.	415	2,410	508	9,250	507	9,270
Gemstones		NA	170	NA	W	NA	W
Peat	thousand metric tons	W	W	W	W	(9/)	12
Salt	do.	4,700	165,000	5,620	191,000	W	W
Sand and gravel (construction)	do.	28,500	130,000	34,900 e/	162,000 e/	28,000	138,000
Stone:							
Crushed	do.	33,400 e/	213,000 e/	38,400	223,000 4/	39,400	239,000
Dimension	metric tons	16,500 e/	2,780 e/	19,300	3,440	24,600 4/	7,370 4/
Combined value of emery (1993), garnet (abrasive), gypsum (crude), lead, sand and gravel (industrial), silver, stone [crushed traprock (1993), dimension granite and quartz(1994)], talc and pyrophyllite, wollastonite, zinc, and values indicated by symbol W		XX	253,000	XX	108,000	XX	354,000
Total		XX	766,000	XX	852,000	XX	892,000
NORTH CAROLINA							
Clays 3/	thousand metric tons	2,120	9,780	2,380	11,200	2,530	12,500
Feldspar	metric tons	439,000	15,500	472,000	16,700	488,000	17,600
Gemstones		NA	1,220	NA	546	NA	565

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NORTH CAROLINA -- Continued							
Mica (scrap)	metric tons	51	$2,970	51	$2,700	68	$3,270
Peat	thousand metric tons	W	108	W	162	21	W
Sand and gravel:							
Construction	do.	9,280	42,700	11,100 e/	53,800 e/	11,100	50,700
Industrial	do.	1,090	17,500	1,340	18,600	1,460	24,200
Stone:							
Crushed 4/	do.	44,100 e/	262,000 e/	47,800	298,000	53,900	351,000
Dimension	metric tons	23,000 e/	7,470 e/	31,700	12,300	33,700	12,500
Combined value of clays (kaolin), lithium minerals, olivine, phosphate rock, stone [crushed quartzite, sandstone, slate, and miscellaneous (1994), crushed quartzite, slate, and volcanic cinder (1993), crushed volcanic cinder (1992)], talc and pyrophyllite, and values indicated by symbol W		XX	236,000	XX	204,000	XX	236,000
Total		XX	596,000	XX	617,000	XX	708,000
NORTH DAKOTA							
Clays	thousand metric tons	W	W	W	W	59	W
Gemstones		NA	643	NA	W	NA	W
Lime	thousand metric tons	101	4,290	W	4,800 r/	W	6,590
Peat	do.	W	W	(9/)	W	W	W
Sand and gravel (construction)	do.	7,930	20,600	7,700 e/	20,400 e/	6,810	18,500
Stone (crushed)	do.	10 e/	W	W	W	--	--
Combined value of clays (common), sand and gravel (industrial), stone (crushed volcanic cinder), and values indicated by symbol W		XX	210	XX	131	XX	199
Total		XX	25,800	XX	25,300 r/	XX	25,300
OHIO							
Cement:							
Masonry	thousand metric tons	103	10,300	93	11,300	W	W
Portland	do.	1,320	77,100	1,490	90,300	1,050	69,700
Clays	do.	2,290	12,100	2,160 3/	12,000 3/	2,080	12,500
Gemstones		NA	5	NA	5	NA	43
Lime	thousand metric tons	1,670	96,700	1,700	101,000	1,850	113,000
Sand and gravel:							
Construction	do.	42,900	178,000	46,400 e/	203,000 e/	47,700	205,000
Industrial	do.	1,280	26,400	1,360	27,500	1,260	27,700
Stone:							
Crushed	do.	44,000 e/ 4/	195,000 e/ 4/	52,200	228,000	56,400	251,000
Dimension	metric tons	31,800 e/	2,240 e/	25,700 4/	1,210 4/	W	W
Combined value of clays [ball (1993-94)], gypsum (crude), peat, salt, silica stone 8/(1992-93), stone [crushed limestone and dolomite (1992), dimension limestone (1993)], and values indicated by symbol W		XX	145,000	XX	176,000	XX	201,000
Total		XX	742,000	XX	851,000	XX	880,000
OKLAHOMA							
Cement:							
Masonry	thousand metric tons	W	W	85	6,720	91	7,410
Portland	do.	931	39,300	1,700	77,600	1,680	102,000
Clays	do.	622	3,300	613	2,940	771	3,910
Gemstones		NA	1,860	NA	W	NA	W
Gypsum (crude)	thousand metric tons	2,360	14,900	2,650	15,400	2,890	17,000
Iodine (crude)	metric tons	2,000	20,900	1,940	15,400	1,630	12,800
Sand and gravel:							
Construction	thousand metric tons	8,980	24,200	9,700 e/	27,300 e/	8,480	27,200
Industrial	do.	972	19,000	1,210	23,200	1,230	24,000
Stone:							
Crushed	do.	24,900 e/ 4/	105,000 e/ 4/	27,100	114,000	29,900	125,000
Dimension	metric tons	4,700 e/	706 e/	2,350 4/	838 4/	3,980 4/	1,250 4/

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
OKLAHOMA -- Continued							
Combined value of feldspar, lime, salt, stone crushed granite (1992), dimension limestone and sandstone (1993)], crushed sandstone (1994)], tripoli, and values indicated by symbol W		XX	$23,100	XX	$14,900	XX	$19,400
Total		XX	253,000	XX	298,000	XX	340,000
OREGON							
Clays	thousand metric tons	203 3/	326 3/	221	1,410	240	1,560
Copper 5/	metric tons	152	361	703	1,420	106	260
Gemstones		NA	2,720	NA	2,140	NA	2,160
Nickel ore 14/	metric tons	6,670	W	2,460	W	--	--
Pumice	do.	W	W	W	W	220,000	2,760
Sand and gravel (construction)	thousand metric tons	15,000	69,500	15,800 e/	74,800 e/	18,400	83,600
Silver 5/	metric tons	(9/)	1	--	--	(6/)	10
Stone (crushed)	thousand metric tons	15,200 e/ 4/	74,900 e/ 4/	18,900	84,700	18,900	90,100
Talc and pyrophyllite	metric tons	64	67	64	67	W	W
Zinc 5/	do.	--	--	--	--	118	128
Combined value of cement [masonry (1992), portland], clays [bentonite (1992)], diatomite, emery, gold 6/ (1992,1994), lime, stone [crushed slate (1992)],and values indicated by symbol W		XX	66,300	XX	61,600	XX	62,100
Total		XX	214,000	XX	226,000	XX	243,000
PENNSYLVANIA							
Cement:							
Masonry	thousand metric tons	296	21,900	248	18,700	245	19,300
Portland	do.	5,020	259,000	5,370	283,000	5,630	315,000
Clays	do.	649	3,460	765	3,780	811	4,040
Gemstones		NA	1	NA	1	NA	1
Lime	thousand metric tons	1,510	94,500	1,540	95,400	1,590	95,500
Peat	do.	15	250	9	249	10	296
Sand and gravel (construction)	do.	17,500	94,600	16,100 e/	83,900 e/	15,900	89,700
Stone:							
Crushed	do.	65,000 e/ 4/	380,000 e/ 4/	69,400 4/	405,000 4/	76,700	462,000
Dimension	metric tons	37,900 e/	10,800 e/	35,700	9,890	43,700 4/	7,280 4/
Combined value of sand and gravel (industrial), stone [crushed dolomite, limestone, and quartzite (1992), crushed quartzite (1993), dimension quartzite and slate (1994)], and tripoli		XX	16,200	XX	13,200	XX	13,300
Total		XX	881,000	XX	913,000	XX	1,010,000
RHODE ISLAND							
Gemstones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand metric tons	2,230	12,000	2,500 e/	13,900 e/	2,310	14,200
Stone (crushed)	do.	1,360 e/	9,500 e/	1,290	9,250	1,610	12,200
Total 11/		XX	21,500	XX	23,200	XX	26,300
SOUTH CAROLINA							
Cement (portland)	thousand metric tons	2,080	93,400	2,130	109,000	2,210	143,000
Clays	do.	1,610	27,700	1,540	31,300	1,520 3/	30,400 3/
Gemstones		NA	641	NA	W	NA	W
Gold 5/	kilograms	6,750	74,800	W	W	W	W
Sand and gravel:							
Construction	thousand metric tons	6,260	19,900	6,800 e/	21,800 e/	8,600	26,100
Industrial	do.	770	17,300	749	19,000	699	18,100
Stone (crushed)	do.	16,000 e/ 4/	83,800 e/ 4/	19,800	121,000	20,000 4/	128,000 4/
Combined value of cement (masonry), manganiferous ore, mica (scrap), peat, silver, stone [crushed dolomite (1992), crushed marble (1994), dimension (1992-93), dimension granite (1994)], vermiculite and values indicated by symbol W		XX	29,300	XX	88,700	XX	87,700
Total		XX	347,000	XX	391,000	XX	433,000

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
SOUTH DAKOTA							
Gemstones		NA	$967	NA	$163	NA	$110
Gold 5/	kilograms	18,700	207,000	19,200	223,000	W	W
Sand and gravel (construction)	thousand metric tons	7,510	22,200	8,300 e/	25,000 e/	7,700	23,700
Silver 5/	metric tons	6	802	5	651	4	696
Stone (crushed)	thousand metric tons	4,080 e/	18,900 e/	4,230 4/	18,700 4/	5,470 4/	24,500 4/
Combined value of cement, clays (common), feldspar, gypsum [crude, (1992-93)], iron ore (usable), lime, mica (scrap), stone [crushed sandstone and miscellaneous (1993), crushed miscellaneous (1994), dimension (1992-93), dimension granite (1994)], and value indicated by symbol W		XX	50,600	XX	69,400	XX	275,000
Total		XX	301,000	XX	337,000	XX	324,000
TENNESSEE							
Clays 3/	thousand metric tons	574	24,100	607	25,700	665	28,600
Gemstones		NA	23,300	NA	21,800	NA	23,100
Sand and gravel:							
Construction	thousand metric tons	7,690	35,100	7,200 e/	34,000 e/	8,710	38,000
Industrial	do.	614	10,700	644	11,700	660	11,600
Stone:							
Crushed	do.	42,400 e/	244,000 e/	43,500	227,000	49,200	265,000
Dimension	metric tons	3,080 e/	320 e/	4,550	552	W	W
Combined value of barite (1994), cement, clays (bentonite, common, fuller's earth), copper, lead, lime, silver, stone [dimension marble (1994)], zinc, and value indicated by symbol W		XX	238,000	XX	189,000	XX	235,000
Total		XX	576,000	XX	510,000	XX	602,000
TEXAS							
Cement:							
Masonry	thousand metric tons	W	W	245	18,400	258	18,200
Portland	do.	6,840	309,000	8,130	398,000	8,620	456,000
Clays 3/	do.	2,240	12,600	2,180	17,400	2,190	13,700
Gemstones		NA	3,830	NA	400	NA	448
Gypsum (crude)	thousand metric tons	1,620	9,920	1,760	10,100	1,870	10,100
Helium (crude)	million cubic meters	W	W	6	5,390	7	7,050
Lime	thousand metric tons	1,340	83,400	1,370 r/	86,400 r/	1,210	76,200
Salt	do.	7,990	76,100	8,250	76,100	8,040	70,500
Sand and gravel:							
Construction	do.	41,400	166,000	47,100 e/	195,000 e/	56,700	242,000
Industrial	do.	1,390	26,500	1,430	28,600	1,570	37,900
Stone (crushed)	do.	64,700 e/	253,000 e/	70,800	279,000	76,100	300,000
Sulfur (Frasch)	do.	1,500	W	1,160	W	W	W
Talc and pyrophyllite	metric tons	236,000	5,720	236,000	5,660	225,000	5,860
Combined value of clays [ball, bentonite, fuller's earth, kaolin), fluorspar (1993), helium (Grade-A), iron ore (usable), magnesium compounds, magnesium metal, sodium sulfate (natural), stone [dimension (1992-93), dimension granite and limestone (1994)], and values indicated by symbol W		XX	357,000	XX	311,000	XX	295,000
Total		XX	1,300,000	XX	1,430,000 r/	XX	1,530,000
UTAH							
Beryllium concentrates	metric tons	4,830	5	4,940	5	4,330	5
Clays 3/	thousand metric tons	243	2,710	216	3,130	243	3,410
Gemstones		NA	634	NA	1,160	NA	620
Potash	thousand metric tons	W	W	210	49,700	W	W
Salt	do.	1,370	44,500	2,250	46,800	1,680	56,700
Sand and gravel (construction)	do.	16,000	54,800	16,000 e/	56,000 e/	21,100	69,600

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
UTAH -- Continued							
Silver 5/	metric tons	W	W	135	$18,700	W	W
Stone (crushed)	thousand metric tons	4,810 e/	$22,400 e/	4,560	29,400	4,540	$19,800
Combined value of cement, clays [bentonite, Fuller's earth (1992-93)], copper, gold, 5/ gypsum (crude), helium [Grade-A, (1994)], iron ore (usable), lime, magnesium compounds, magnesium metal, mercury, molybdenum, phosphate rock, sodium sulfate [natural (1992-93)], stone [dimension (1993), dimension quartzite and sandstone (1994)], and values indicated by symbol W		XX	1,220,000	XX	1,110,000	XX	1,370,000
Total		XX	1,350,000	XX	1,310,000	XX	1,520,000
VERMONT							
Asbestos	metric tons	4,580	1,690	3,660	1,530	1,130	920
Gemstones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand metric tons	3,150	11,300	3,000 e/	10,400 e/	3,890	14,500
Stone:							
Crushed	do.	2,270 e/	12,200 e/	2,520	12,900	4,170	23,700
Dimension	metric tons	113,000 e/	34,600 e/	97,400	27,900	13,500 4/	9,500 4/
Total 11/		XX	59,800	XX	52,700	XX	48,600
VIRGINIA							
Cement (portland)	thousand metric tons	W	W	W	W	930	54,700
Clays 3/	do.	754	3,370	775	2,950	870	3,250
Lime	do.	764	40,300	756	40,000	742	40,200
Sand and gravel (construction)	do.	8,660	37,300	9,000 e/	40,500 e/	8,060	33,400
Stone:							
Crushed	do.	43,100 e/	261,000 e/	51,000	292,000	56,700	327,000
Dimension	metric tons	W	W	W	W	108 4/	13 4/
Combined value of cement (masonry), clays [bentonite (1992-93), fuller's earth], feldspar, gemstones, gypsum (crude), iron oxide pigments (crude), kyanite, sand and gravel (industrial), stone [dimension (1992-93), dimension granite and slate (1994)], talc and pyrophyllite, vermiculite, and values indicated by symbol W		XX	120,000	XX	88,900	XX	43,600
Total		XX	462,000	XX	465,000	XX	502,000
WASHINGTON							
Clays 3/	thousand metric tons	306	1,890	238	1,370	246	1,140
Gemstones		NA	379	NA	24	NA	1,050
Gold 5/	kilograms	8,800	97,600	7,110	82,500	7,410 6/	91,800 6/
Lime	thousand metric tons	W	W	213	W	239	W
Peat	do.	W	W	W	W	3	111
Sand and gravel (construction)	do.	37,100	141,000	40,200 e/	158,000 e/	39,600	165,000
Silver 5/	metric tons	W	W	14	1,940	W	W
Stone (crushed)	thousand metric tons	12,200 e/	63,200 e/	13,200	68,600	15,500	86,100
Combined value of cement, clays (fire), diatomite, lead (1992-93), magnesium metal, olivine, sand and gravel (industrial), stone [dimension (1992-93), dimension miscellaneous (1994)], zinc (1992-93), and values indicated by symbol W		XX	165,000	XX	193,000	XX	226,000
Total		XX	469,000	XX	505,000	XX	571,000
WEST VIRGINIA							
Clays	thousand metric tons	80	221	115	334	138	291
Gemstones		NA	1	NA	1	NA	1
Sand and gravel (construction)	thousand metric tons	1,260	5,730	1,400 e/	6,700 e/	1,380	5,970
Stone (crushed)	do.	10,300 e/	57,800 e/	10,300 4/	79,700	12,300 4/	99,300

See footnotes at end of table.

TABLE 6 -- Continued
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE UNITED STATES, BY STATE

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
WEST VIRGINIA -- continued							
Combined value of cement, lime, peat, salt, sand and gravel (industrial), and stone [dimension (1994)]		XX	$47,800	XX	$62,800	XX	$75,500
Total		XX	112,000	XX	149,000	XX	181,000
WISCONSIN							
Gemstones		NA	5	NA	45	NA	53
Lime	thousand metric tons	473	26,600	511	30,900	507	30,300
Peat	do.	56	553	W	W	2	61
Sand and gravel:							
Construction	do.	26,400	77,100	27,600 e/	82,800 e/	29,200	91,500
Industrial	do.	1,300	26,000	1,480	31,400	1,630	32,400
Silica stone 8/	metric tons	W	W	W	W	45	80
Stone:							
Crushed	thousand metric tons	23,100 e/ 4/	89,300 e/ 4/	26,200	98,000	28,500	114,000 4/
Dimension	metric tons	32,800 e/	4,230 e/	122,000	13,100	125,000	14,100
Total 4/		XX	224,000	XX	256,000	XX	283,000
WYOMING							
Cement (portland)	thousand metric tons	438	30,200	W	W	W	W
Clays 3/	do.	2,530	83,100	2,180 r/	63,300 r/	2,530	91,300
Gemstones		NA	12	NA	13	NA	13
Sand and gravel (construction)	thousand metric tons	2,850	11,400	3,400 e/	15,000 e/	3,210	13,100
Stone (crushed)	do.	4,080 e/	19,900 e/	3,460	19,800	5,080	30,000
Combined value of cement [masonry (1992-93)], clays (common), gypsum [crude (1994)], helium (Grade-A), lime, soda ash, and values indicated by symbol W		XX	804,000	XX	746,000	XX	746,000
Total		XX	949,000	XX	844,000 r/	XX	880,000
UNDISTRIBUTED							
Delaware, Hawaii (1992), Mississippi (1993-94), New Hampshire (1992, 1994), Rhode Island, Vermont, and Wisconsin		XX	25,600 r/	XX	95,700 r/	XX	155,000

e/ Estimated. r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data, value included with "Combined value" data.

XX Not applicable.

1/ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

3/ Excludes certain clays; kind and value included with "Combined value" data.

4/ Excludes certain stones; kind and value included with "Combined value" data.

5/ Recoverable content of ores, etc.

6/ Placer canvassing discontinued beginning 1994. May include placer data from other sources.

7/ Pyrites canvassing discontinued beginning 1994.

8/ Formerly identified as "abrasives." Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

9/ Less than 1/2 unit.

10/ Calcium chloride canvassing discontinued beginning 1993.

11/ Partial total, excludes values which must be concealed to avoid disclosing company proprietary data.

12/ Value excluded to avoid disclosing company proprietary data.

13/ Excludes salts in brines; value included with "Combined value" figure.

14/ The Riddle nickel smelter uses lateritic ore mined on Nickel Mountain, lateritic ore imported from New Caledonia, and small tonnages of recycled Ni-bearing catalysts. In 1989, the Glenbrook Nickel Co. purchased the idle mining and smelting complex and restarted the operation. Production of ferronickel on a contained Ni basis has been as follows: 1992--8,960 metric tons (mt) valued at $62.7 million; 1993--4,880 mt valued at $28.0 million; and in 1994 the Nickel Mountain mine was idle.

TABLE 7
NONFUEL RAW MINERAL PRODUCTION 1/ 2/ IN THE COMMONWEALTH OF PUERTO RICO AND ISLANDS ADMINISTERED BY THE UNITED STATES

Mineral		1992		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
PUERTO RICO							
Cement (portland)	thousand metric tons	1,300	$120,000	1,310	$72,600	W	W
Clays	do.	W	527	155	508	119	$338
Lime	do.	27	3,720	--	--	23	2,970
Sand and gravel (industrial)	do.	W	W	58	1,400	W	W
Stone (crushed)	do.	NA	NA	7,850	51,100	10,500	78,400
Total		XX	124,000 3/	XX	126,000	XX	81,700 3/
ADMINISTERED ISLANDS							
American Samoa: Stone (crushed)	thousand metric tons	--	--	83	W	84	W
Guam: Stone (crushed)	do.	--	--	1,370	15,100	2,150	12,700
Total		XX	--	XX	15,100 3/	XX	12,700 3/

e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Total does not include value of item withheld.

TABLE 8
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS					
Aluminum:					
Aluminum oxide (alumina, includes hydroxide [calcined equivalent])	thousand metric tons	1,240	$306,000	1,040	$271,000
Crude and semicrude	metric tons	1,210,000	2,230,000	1,370,000	2,730,000
Manufactures	do.	98,500	270,000	138,000	352,000
Speciality compounds (aluminum sulfate, aluminum chloride, aluminum oxide abrasives, and various fluorine-based compounds)	do.	52,200	NA	46,900	NA
Antimony:					
Metal, alloys, waste and scrap	do.	315	871	1,350	7,470
Oxide (antimony content)	do.	3,900	8,890	6,500	15,000
Arsenic metal	do.	364	1,210	79	411
Bauxite (dried and calcined)	thousand metric tons	85 r/	NA	114	NA
Beryllium (alloys, wrought or unwrought, and waste and scrap)	kilograms	19,700	1,760	28,500	2,700
Bismuth (metal, alloys, waste and scrap)	do.	70,100	790	160,000	1,060
Cadmium:					
Metal	do.	38,000	471	1,450,000	2,770
Sulfide	do.	31,400	29,800	205,000	119,000
Chromium:					
Chemicals	metric tons	20,000	34,900	29,500	44,000
Chromite ore and concentrate	do.	10,000	2,140	47,100	3,550
Metal and alloys	do.	15,700	18,400	12,400	16,500
Pigments	do.	2,310	9,400	1,310	6,010
Cobalt:					
Metal (unwrought, powders, waste and scrap, and mattes and other intermediate products of metallurgy)	do.	435	10,900	1,050	32,500
Metal (wrought and cobalt articles)	do.	249	11,400	665	24,500
Ores and concentrates	do.	9	78	71	558
Oxides and hydroxides	do.	308	6,080	327	7,420
Other forms (acetates and chlorides)	do.	563	4,100	309	2,930
Columbium:					
Ferrocolumbium	do.	815	7,310	234	2,080
Ores and concentrates	do.	6	46	489	4,500
Copper:					
Scrap (alloyed and unalloyed)	do.	262,000	280,000	360,000	437,000
Semimanufactures [pipes and tubing, plates, sheets, foil, bars, bare wire (including wire rod), wire and cable (stranded), and sulfate]	do.	100,000	384,000	106,000	378,000
Unmanufactured (ore and concentrates, matte, ash and precipitates, refined, unalloyed scrap, blister and anodes)	do.	578,000	854,000	596,000	943,000
Gold:					
Bullion (refined)	kilograms	658,000	7,610,000	334,000	4,060,000
Doré and precipitates	do.	67,500	686,000	60,600	677,000
Ores and concentrates	do.	216	1,880	462	3,780
Waste and scrap	do.	66,800	616,000	76,300	745,000
Iron ore	thousand metric tons	5,060	167,000	4,890	163,000
Iron and steel:					
Ferroalloys not elsewhere listed:					
Ferrophosphorous	do.	1,810	1,040	29,100	4,960
Ferrozirconium	do.	20	54	131	161
Ferroalloys (n.e.c.)	do.	2,030	2,820	3,280	4,520
Products:					
Cast iron and steel	thousand metric tons	180	348,000	183	357,000
Fabricated steel	do.	631	1,960,000	866	2,190,000
Steel mill	do.	3,600	2,490,000	3,470	3,010,000
Other steel	do.	57	44,300	(2/)	(2/)
Scrap:					
Direct-reduced iron (steelmaking grade)	do.	17 r/	1,860 r/	17	1,850
Pig iron	do.	27	3,040	56	6,780
Heavy melting, bundles, shredded steel, borings, shovelings, and turnings, cut plate and structural, tinned (iron or steel), remelting ingots, stainless steel, other steel (alloys, tinplate and terneplate)	do.	9,810	1,320,000	8,810	1,270,000

See footnotes at end of table.

TABLE 8 -- Continued
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS -- Continued					
Iron and steel: -- Continued					
Scrap: -- Continued					
Ships, boats, and other vessels for scrapping	thousand metric tons	162	$13,200	106	$9,420
Used rails for rerolling and other uses [includes mixed (used plus new) rails]	do.	43	11,800	35	8,900
Lead:					
Ash and residues (lead content)	metric tons	1,730	1,330	20,600	11,100
Ore and concentrate (lead content)	do.	41,800	7,840	38,700	11,200
Scrap	do.	54,100	14,400	88,100	24,500
Unwrought metal and alloys (lead content)	do.	51,400	32,200	48,200	29,500
Wrought metal and alloys (lead content)	do.	7,140	19,700	5,340	19,300
Magnesium:					
Alloys	do.	1,950	8,220	5,630	16,900
Metal	do.	26,500	71,900	25,600	65,700
Powder, sheets, tubing, ribbons, wire, and other forms	do.	8,340	18,800	12,100	21,000
Waste and scrap	do.	2,010	4,640	1,840	4,280
Manganese:					
Ferromanganese (all grades)	do.	18,000	14,800	11,000	9,470
Metal (including alloys, waste, and scrap)	do.	3,840	9,400	4,870	10,200
Ore and concentrates	do.	15,900	1,790	15,300	1,550
Silicomanganese	do.	9,420	6,720	6,840	5,490
Mercury	do.	389	1,230	316	885
Molybdenum (molybdenum content):					
Ferromolybdenum	do.	224	2,960	479	5,200
Ore and concentrates	do.	28,300	74,200	33,600	199,000
Oxides and hydroxides (gross weight)	do.	1,040	5,610	2,240	13,700
Molybdates (all)	do.	958	4,790 r/	1,800	10,000
Powder (gorss weight)	do.	203 r/	3,760 r/	168	4,320
Unwrought (gross weight)	do.	52	801	396	4,980
Wire (gross weight)	do.	261 r/	10,200 r/	221	10,000
Wrought (gross weight)	do.	94 r/	4,790	103	6,050
Nickel (nickel content):					
Alloyed (unwrought ingots, bars, rods, profiles, wire, sheets, strips, foil, tubes, pipes, and other articles)	do.	14,900	232,000 r/	17,000	226,000
Chemicals	do.	1,440	59,000	2,110	67,800
Unwrought:					
Primary (cathodes, pellets, briquets, shot, ferronickel, powder, flakes, and metallurgical-grade oxide)	do.	5,750	21,100	5,330	21,500
Secondary (scrap [stainless steel and waste])	do.	26,000	179,000 r/	34,500	235,000
Wrought (bars, rods, profiles, wire, sheets, strip, foil, tubes, and pipes)	do.	551	5,760	427	5,920
Platinum-group metals [platinum, palladium, rhodium, iridium, osmium, ruthenium, (ores and concentrates, waste and scrap, and refined)]	kilograms	78,500	441,000	88,600	375,000
Rare-earth metals (rare-earth oxide content):					
Cerium compounds	do.	1,620,000	11,700	4,460,000	24,400
Compounds	do.	1,090,000	14,100	2,420,000	12,500
Ferrocerium and pyrophoric alloys	do.	4,810,000	20,400	3,400,000	12,000
Metals (including scandium and yttrium)	do.	161,000	2,400	274,000	1,570
Selenium (metal, waste and scrap, selenium content)	do.	261,000	2,200	246,000	2,280
Silicon:					
Ferrosilicon	metric tons	39,500	36,800	38,000	36,300
Metal	do.	10,600	133,000	12,100	140,000
Silver:					
Bullion (refined)	kilograms	705,000	100,000	868,000	155,000
Doré and precipitates	do.	103,000	16,000	99,100	17,500
Ores and concentrates	do.	2,270	395	196	41
Waste and scrap	do.	892,000	142,000	1,210,000	211,000
Tantalum:					
Ores and concentrates (includes synthetic)	thousand kilograms	11	111	25	328
Unwrought (alloys, metal, powders, and waste and scrap)	do.	242	24,900	200	21,100
Wrought	do.	50	18,700	88	25,600

See footnotes at end of table.

TABLE 8 -- Continued
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS -- Continued					
horium:					
Compounds	kilograms	189	$68	7	$13
Ore (monazite concentrate)	do.	W	W	33,000	21,100
in:					
Ingots and pigs	metric tons	2,600	11,400	2,560	13,900
Tin scrap and other tin bearing material (except tinplate scrap, includes bars, rods, profiles, wire, powders, flakes, tubes, and pipes)	do.	92,600	63,200	68,000	52,800
Tinplate and terneplate	do.	201,000	120,000	213,000	123,000
itanium:					
Metal:					
Scrap	do.	3,890	9,070	4,120	7,440
Sponge	do.	104	748	126	738
Other unwrought (billet, blooms and sheet bars, ingots, etc.)	do.	1,500	27,100	1,600	27,700
Wrought (bars, rods, etc.)	do.	2,390	72,700	3,850	131,000
Ores and concentrates	do.	15,200	4,890	19,000	6,070
Pigments (dioxides and oxides)	do.	290,000	405,000	352,000	485,000
ungsten (tungsten content):					
Ammonium paratungstate	do.	166	2,210	250	2,200
Carbide powder	do.	1,250	22,500	1,320	27,600
Metal and alloy powder	do.	416	7,860	477	12,500
Miscellaneous tungsten-bearing materials (ferrotungsten and ferrosilicon tungsten, unwrought, wire [metal and alloy], wrought, other compounds [other tungstates], and other metal)	do.	550	24,000	1,080	24,100
Ore and concentrate	do.	63	309	44	209
anadium:					
Aluminum-vanadium master alloy	kilograms	866,000 r/	10,800	1,030,000	12,900
Compounds (pentoxide [anhydride], and other [excludes vanadates], vanadium content)	do.	1,020,000	5,260	1,390,000	7,870
Ferrovanadium	do.	219,000 r/	2,780	374,000	4,410
inc:					
Basic materials (including waste and scrap)	metric tons	XX	197,000	XX	224,000
Compounds (chloride, lithopone, oxide, sulfate, sulfide, and compounds n.s.p.f.)	do.	17,300	50,400	25,300	31,100
Ore and concentrates (zinc content)	do.	311,000	117,000	389,000	157,000
Rolled	do.	6,600	6,400	6,680	4,760
Slab	do.	1,410 r/	1,510	6,310	7,390
irconium:					
Ore and concentrates	do.	35,900	13,200	32,000	13,900
Unwrought and waste and scrap	do.	248	6,150 r/	223	6,570
Metal totals		XX	22,700,000 r/	XX	21,400,000
INDUSTRIAL MINERALS					
brasive materials:					
Manufactured (Fused aluminum oxide, metallic abrasives, silicon carbide)	metric tons	57,100	59,000	60,900	60,200
Special silica	do.	1,990	6,760	XX	8,600
sbestos (includes reexports):					
Manufactured		XX	141,000	XX	177,000
Unmanufactured	metric tons	27,600	8,440	17,500	6,550
arite (natural barium sulfate)	do.	18,500	2,610	13,800	1,850
oron:					
Boric acid	thousand metric tons	75 r/	50,500	87	53,300
Sodium borates	do.	481	181,000	498	165,000
romine:					
Compounds (contained bromine)	thousand kilograms	13,400	21,800	11,500	21,100
Elemental	do.	6,010	7,440	6,470	7,270
ement: Hydraulic and clinker	thousand metric tons	625	47,800	(2/)	(2/)
lays:					
Ball	do.	60	3,200	81	3,470
Bentonite	do.	606	55,400	768	69,500
Fire	do.	148	14,800	225	24,300
Fuller's earth	do.	63	7,630	74	9,820

ee footnotes at end of table.

TABLE 8 -- Continued
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS -- Continued					
Clays: -- Continued					
Kaolin	thousand metric tons	2,980	$488,000	3,180	$532,000
Other (includes chamotte or dinas earth, activated clays and earths, and artificially activated clays)	do.	293	100,000	295	100,000
Diatomite	do.	165	49,900	157	56,600
Diamonds (industrial):					
Industrial stones [incliding glazer's and engraver's unset, and miner's (natural and synthetic)]	thousand carats	1,040	4,980	4,400	89,600
Powder and grit (natural and synthetic)	do.	105,000	137,000	153,000	143,000
Feldspar	metric tons	17,700	1,840	17,300	1,940
Fluorspar	do.	12,700	2,130	23,500	3,690
Garnet (abrasive)	do.	11,400	XX	10,000	XX
Gemstones (includes reexports):		XX	1,630,000	XX	2,240,000
Graphite (nautral and artificial)	metric tons	52,400	42,000	58,100	52,500
Gypsum:					
Boards	thousand metric tons	91	24,600	74	19,800
Crude	do.	69	3,640	89	4,090
Plasters	do.	156	21,200	153	22,800
Other	do.	XX	28,200	XX	26,700
Helium (Grade-A)	million cubic meters	28	67,000	25	49,600
Iodine:					
Crude/resublimed	metric tons	1,020	8,560	1,160	9,070
Potassium iodide	do.	203	1,180	90	990
Iron oxide pigments:					
Pigment grade	do.	22,400	32,000	21,300	30,700
Other grade	do.	139,000	92,500	229,000	94,800
Lime	thousand metric tons	69	7,830	74	7,800
Lithium compounds:					
Carbonate	metric tons	6,260	22,200	5,260	18,100
Hydroxide	do.	3,060	13,200	3,600	16,600
Magnesium compounds:					
Calcined dolomite	do.	13,700	2,820	(2/)	(2/)
Caustic-calcined magnesia	do.	4,450	2,460	3,240	1,780
Compounds (chlorides, hydroxide and peroxide, and sulfates)	do.	9,890	7,930	20,900	10,400
Dead-burned and fused magnesia	do.	59,800	21,800	59,800	22,800
Magnesite (crude)	do.	7,390	3,010 r/	8,570	987
Other magnesia	do.	22,000	11,100	12,700	8,660
Mica:					
Scrap and flake:					
Powder	do.	4,610	2,600	(2/)	(2/)
Waste	do.	335	99	(2/)	(2/)
Sheet:					
Unworked	do.	292	511	(2/)	(2/)
Worked	do.	617	9,020	(2/)	(2/)
Nitrogen compounds (major):					
Anhydrous ammonia	thousand metric tons	460	NA	261	NA
Fertilizer materials	do.	10,900	NA	13,400	NA
Industrial chemicals	do.	149	119,000	169	156,000
Peat	do.	8	900	23	2,200
Perlite (crude)	metric tons	26,000	1,000	30,000	900
Phosphorus:					
Diammonium and monoammonium phosphates	thousand metric tons	8,460	NA	10,700	NA
Elemental phosphorous	metric tons	18,400	32,200	15,200	26,400
Phosphate rock:					
Ground and unground	thousand metric tons	3,570	NA	3,310	NA
Phosphoric acid	do.	498	NA	516	NA
Superphosphates	do.	762	NA	801	NA
Potash:					
Potassium chloride (all grades)	metric tons	361,000	NA	419,000	NA
Potassium magnesium sulfate	do.	333,000	NA	298,000	NA

See footnotes at end of table.

TABLE 8 -- Continued
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS -- Continued					
Potash: -- Continued					
Potassium nitrate	metric tons	8,000	NA	6,510	NA
Potassium sulfate	do.	223,000	NA	273,000	NA
Pumice and pumicite	thousand metric tons	18 e/	$462 e/	18	$5,700
Quartz crystal (cultured)	thousand kilograms	24	2,260	38	6,110
Salt	thousand metric tons	688	34,800	742	30,200
Sand and gravel:					
Construction:					
Gravel	do.	534	5,000	482	4,640
Sand	do.	597	10,600	564	15,600
Industrial	do.	1,750	91,000	1,880	102,000
Sodium compounds:					
Soda ash	thousand metric tons	2,800	376,000	3,230	406,000
Sodium sulfate	do.	89	8,540	65	7,020
Stone:					
Crushed	metric tons	4,820,000	39,300	5,180,000	38,100
Dimension	thousand short tons	NA	57,900	NA	(2/)
Strontium compounds (precipitated carbonate, oxide, hydroxide, and peroxide)	kilograms	429 r/	451	1,860	908
Sulfur:					
Elemental	thousand metric tons	656	39,700	899	48,400
Sulfuric acid (100% H2SO4)	metric tons	145,000 r/	11,200 r/	140,000	11,100
Talc (excludes talcum in packages, face, and compact)	thousand metric tons	135	27,200	154	29,800
Vermiculite	do.	7 e/	NA	7 e/	NA
Industrial minerals totals		XX	4,300,000 r/	XX	5,060,000
Total		XX	27,000,000 r/	XX	26,500,000

r/ Revised. NA Not available. XX Not applicable.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits.

2/ Data not available at time of table compilation.

3/Artificial graphite includes large amounts of materials made from petroleum coke.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS					
Aluminum:					
Aluminum oxide (alumina)	thousand metric tons	3,940	$754,000	3,120	$623,000
Crude and semicrude	metric tons	2,540,000	3,260,000	3,380,000	5,000,000
Manufactures	do.	56,000	163,000	100,000	245,000
Antimony:					
Metal	do.	14,400	25,600	18,200	61,700
Ore and concentrate (antimony content)	do.	543	1,070	5,640	16,900
Oxides (antimony content)	do.	16,000	24,800	17,700	41,800
Arsenic:					
Acid	do.	--	--	5	10
Metal	do.	767	2,400	1,330	3,410
Trioxide	do.	27,500	15,900	26,800	15,200
Bauxite:					
Calcined	thousand metric tons	237	17,000	349	19,100
Crude and dried	do.	11,600	NA	10,700	NA
Beryllium:					
Beryl	metric tons	58	NA	--	--
Metal and compounds	kilograms	116,000	1,690	235,000	4,170
Bismuth metals and alloys	do.	1,330,000	6,250	1,660,000	9,650
Cadmium:					
Metal	do.	1,410,000	1,690	1,110,000	2,170
Sulfide	do.	10,800	143	43,500	272,000
Chromium:					
Chemicals	metric tons	15,500	21,700	20,600	29,300
Chromite ore	do.	255,000	16,500	201,000	13,900
Ferrochromium (all grades)	do.	387,000	184,000	317,000	148,000
Metals and alloys [metal (waste and scrap and other), and ferrochromium-silicon]	do.	14,900	44,100	21,600	47,100
Pigments and preparations based chromium	do.	4,980	12,700	6,400	16,400
Cobalt:					
Metal (alloys, articles, matte, wrought, and waste and scrap)	do.	752	16,900	1,040	20,800
Metal (unwrought, excluding alloys and waste and scrap)	do.	5,390	166,000	5,890	248,000
Oxide and hydroxides	do.	444	12,600	763	26,100
Other forms (acetates, carbonates, chlorides, and sulfates)	do.	842	7,320	1,250	12,100
Columbium:					
Ferrocolumbium	thousand kilograms	3,370	29,000	3,980	34,000
Ores and concentrates	do.	2,350	8,610	3,080	11,400
Oxide	do.	301	5,390	757	11,600
Unwrought (alloys, metals, and powders)	do.	111	2,380	171	3,770
Copper:					
Scrap (alloyed and unalloyed)	metric tons	200,000	307,000	160,000	265,000
Semimanufactures [pipes and tubing, plates, sheets, foil, bars, bare wire (including wire rod), wire and cable (stranded), and sulfate]	do.	79,800	267,000	94,100	290,000
Unmanufactured (ore and concentrates, matte, ash and precipitates, blister and anode, refined, unalloyed scrap)	do.	526,000	993,000 r/	675,000	1,430,000
Gallium (unwrought, waste and scrap)	kilograms	15,600	4,130 r/	16,900	3,550
Germanium materials	do.	15,500	5,300	14,700	5,140
Gold:					
Bullion (refined)	do.	130,000	1,500,000	96,400	1,180,000
Doré and precipitates	do.	12,500	135,000	15,100	174,000
Ore and concentrates	do.	1,240	13,500	2,250	27,300
Waste and scrap	do.	25,500	65,400	21,800	111,000
Hafnium (unwrought, and waste and scrap)	metric tons	3	669	5	871
Indium (unwrought, and waste and scrap)	kilograms	73,400	11,500	70,200	8,950
Iron ore	thousand metric tons	14,100	419,000 r/	17,500	499,000
Iron and steel:					
Ferroalloys not elsewhere listed:					
Ferrophosphorus	do.	9,970	2,330	15,200	5,170
Ferrotitanium and ferrosilicon-titanium	do.	45,400	8,070	6,340	11,200
Ferrozirconium	do.	267	506	60	108

See footnotes at end of table.

TABLE 9 -- Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS -- Continued					
Iron and steel: -- Continued					
Ferroalloys not elsewhere listed: -- Continued					
Ferroalloys (n.e.c.)	thousand metric tons	16,500	$34,900	22,400	$30,600
Products:					
Cast iron and steel	do.	228	217,000	272	259,000
Fabricated steel	do.	2,050	3,760,000	2,360	3,840,000
Steel mill	do.	17,700	8,630,000	27,300	12,400,000
Pig iron	do.	828	117,000	2,440	342,000
Scrap:					
Direct-reduced iron (steelmaking grade)	do.	1,090	104,000	1,170	138,000
Heavy melting, bundles, shredded steel, borings, shovelings, and turnings, cut plate and structural, tinned (iron or steel), remelting ingots, stainless steel, other steel (alloys, tinplate and templates)	do.	1,390 r/	162,000 r/	1,710	215,000
Ships, boats, and other vessels for scrapping	do.	(2/)	82	(2/)	210
Used rails for rerolling and other uses	do.	70	13,600	183	31,500
Stainless steel (bars, pipe, plate, semifinished, shapes, sheet, strip, tube, wire and wire rods)	metric tons	611,000	NA	(3/)	NA
Lead:					
Base bullion (lead content)	do.	18	62	577	284
Ore and concentrates (lead content)	do.	483	347	473	138
Pigments and compounds	do.	30,900	33,600	36,700	43,600
Pigs and bars (lead content)	do.	196,000	85,100	231,000	134,000
Scrap (reclaimed,includes ash and residues, lead content)	do.	78 r/	39	144	80
Wrought (all forms, including wire and powders, gross weight)	do.	6,890	10,300	5,820	12,100
Magnesium:					
Alloys (magnesium content)	do.	8,080	27,500	9,540	33,800
Metal	do.	24,200	53,100	15,700	36,200
Powder, sheets, tubing, ribbons, wire, and other forms (magnesium content)	do.	1,470	4,620	981	3,510
Waste and scrap	do.	3,460	4,520	2,920	4,190
Manganese:					
Chemicals (manganese dioxide and potassium permanganate)	do.	25,400	38,200	31,300	47,200
Metal	do.	15,100	22,500	20,300	28,800
Ore and concentrates (manganese content)	do.	232,000	24,900 r/	331,000	29,800
Ferromanganese (all grades, manganese content)	do.	542,000	335,000	530,000	338,000
Silicomanganese (manganese content)	do.	208,000	133,000	181,000	123,000
Mercury (metal, mercury-bearing waste and scrap)	do.	40	143	129	494
Molybdenum (molybdenum content):					
Ferromolybdenum	do.	2,190	12,700	2,960	23,200
Molybdates (all)	do.	317	2,630	362	2,630
Ore and concentrates	do.	3,400	17,000	2,280	15,900
Oxides and hydroxides (gross weight)	do.	622	2,880	628	3,950
Powder	do.	52	2,090	89	2,770
Unwrought	do.	136	1,750	52	1,060
Wire (gross weight)	do.	3	308	2	304
Wrought (gross weight)	do.	49	3,430	--	--
Other (inorganic compounds, orange, waste and scrap, and other, gross weight)	do.	1,080 r/	5,550	1,420	9,410
Nickel (nickel content):					
Alloyed (unwrought ingots, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes, other articles)	do.	7,050	80,800	7,680	81,900
Chemicals (catalysts and salts)	do.	4,030	56,900	3,950	53,400
Ore	do.	2,970	W	--	--
Unwrought:					
Primary (cathodes, pellets, briquets, shot, ferronickel, flakes, powder, metallurgical-grade oxide)	do.	122,000	660,000	123,000	737,000
Secondary (scrap [stainless steel and waste])	do.	6,710	39,300	6,060	41,900
Wrought (bars, rods, profiles, wire, sheets, strips, foil, tubes, and pipes)	do.	991	15,400	634	8,740

See footnotes at end of table.

TABLE 9 -- Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS -- Continued					
Platinum-group metals [platinum, palladium, rhodium, iridium, osmium, ruthenium, (ores and concentrates, waste and scrap, and refined)]	kilograms	153,000	$1,310,000	171,000	$1,400,000
Rare-earth metals (rare-earth oxide content):					
Cerium compounds (including chlorides, hydroxides, nitrates, oxides, oxilate, and sulfates)	do.	1,270,000	10,000	1,890,000	15,400
Compounds (including hydroxides, nitrates, oxides, and others, except chlorides)	do.	4,980,000	39,400	5,140,000	44,400
Chloride mixtures (except cerium chloride)	do.	2,360,000	8,090	2,410,000	11,400
Ferrocerium and other pyrophoric alloys	do.	118,000	1,650	77,400	1,170
Oxide mixtures (except cerium oxides)	do.	249,000	10,600	354,000	10,300
Rare-earth metals (whether intermixed or alloyed)	do.	196,000	2,640	284,000	4,450
Rhenium:					
Ammonium perrhenate	do.	3,170	1,600	2,330	1,010
Metal	do.	2,700	3,330	5,870	5,890
Selenium: (selenium content)					
Selenium dioxide	do.	14,500	143 r/	15,300	173
Unwrought, and waste and scrap	do.	367,000	6,880	396,000	7,420
Silicon:					
Ferrosilicon	metric tons	200,000 r/	111,000	204,000	125,000
Metal	do.	72,200	126,000	100,000	152,000
Silver:					
Bullion (refined)	kilograms	2,180,000	297,000	2,060,000	347,000
Doré and precipitates	do.	281,000	78,600	413,000	124,000
Ore and concentrates	do.	35,700	6,410	133,000	24,100
Waste and scrap	do.	1,270,000	46,000	1,070,000	55,100
Tantalum:					
Ores and concentrates (includes synthetic)	thousand kilograms	1,290	32,700	1,120	25,600
Unwrought (alloys, metal, powders, and waste and scrap)	do.	165	14,800	340	26,100
Wrought	do.	3	547	1	368
Tellurium (unwrought, and waste and scrap)	kilograms	45,000	3,180	27,400	1,570
Thallium (unwrought waste and scrap)	do.	273	35	(3/)	(3/)
Thorium:					
Compounds	do.	18,300	479	3,150	140
Tin:					
Compounds	metric tons	431	3,150	744	4,740
Metal (unwrought)	do.	33,700	176,000 r/	32,400	171,000
Miscellaneous tin and tin manufactures (alloys [n.s.p.f.], dross, flitters, foil, metallics, powder, residues, scrap, skimmings, and manufactures [n.s.p.f.])	do.	XX	30,300	XX	42,100
Tinplate and terneplate	do.	237,000	161,000	337,000	216,000
Tinplate scrap	do.	12,600	1,420	8,950	1,410
Titanium:					
Concentrates:					
Ilmenite	do.	301,000	18,400	336,000	26,200
Rutile (natural and synthetic)	do.	371,000	135,000	332,000	124,000
Titaniferous iron ore	do.	66,300	2,850	43,700	2,270
Titanium slag	do.	476,000	150,000	472,000	158,000
Metal:					
Ingots and billets	do.	272	3,030	1,730	15,500
Powder	do.	37	813	(3/)	(3/)
Unwrought	do.	2,160	10,500	6,470	22,500
Waste and scrap	do.	5,520	18,100	5,870	19,100
Wrought (bars, castings, foil, pipes, plates, profiles, rods, sheet, strip, tubes, wire, and other)	do.	600	17,200	801	23,700
Other (includes bars, blooms, sheet, slabs, and other unwrought)	do.	131	761	644	4,340
Pigments (dioxides and oxides)	do.	172,000	284,000	176,000	283,000
Tungsten (tungsten content):					
Ammonium paratungstate	do.	1,180	6,480	848	5,220
Ferrotungsten	do.	652	2,830	515	1,880

See footnotes at end of table.

TABLE 9 -- Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
METALS -- Continued					
Tungsten (tungsten content): -- Continued					
Miscellaneous tungsten-bearing materials (carbide, chlorides, oxides, unwrought, tungstates [calcium and sodium], waste and scrap, wrought, and other tungsten-bearing material)	metric tons	3,960	$42,300	6,410	$48,400
Ore and concentrates	do.	1,720	7,840	2,960	9,110
Vanadium:					
Aluminum-vanadium master alloy (vanadium content)	kilograms	1,630,000	12,200	1,910,000	12,900
Metal (including waste and scrap)	do.	630,000	5,520	570,000	5,880
Pentoxide (anhydride, vanadium content)	do.	69,800	381	294,000	1,770
Other oxides and hydroxides	do.	18,700	292	3,470	41
Vanadium-bearing materials (ash, residues, slag, other [includes spent catalyst], pentoxide content)	do.	2,590,000	3,320	3,390,000	2,070
Miscellaneous chemicals (vanadates, hydrides, and nitrides)	do.	66,800	749	29,700	454
Zinc:					
Pigments and compunds (chloride, lithopone, oxide, sulfate, sulfide, and compounds n.s.p.f.)	metric tons	48,600	53,200	55,100	59,700
Ore and concentrates (zinc content)	do.	33,100	11,800	27,400	10,500
Rolled	do.	135	353	475	744
Slab	do.	724,000	502,000	793,000	518,000
Zirconium:					
Ore and concentrates	do.	70,000	9,320	82,000	14,900
Unwrought and waste and scrap	do.	121	1,170 r/	188	1,110
Metal totals		XX	27,000,000 r/	XX	34,200,000
INDUSTRIAL MINERALS					
Abrasive materials:					
Manufactured (Fused aluminum oxide, metallic abrasives, silicon carbide)	metric tons	299,000	149,000	153,000	143,000
Silica stone	do.	XX	2,390	XX	2,400
Asbestos (unmanufactured)	do.	30,800	6,960	25,800	5,390
Barite:					
Barium chemicals	do.	30,300	24,500	39,300	29,400
Crude and ground	do.	804,000	34,200	1,080,000	47,200
Boron (contained boric oxide):					
Borax	thousand metric tons	40	1,230	9	2,700
Boric acid	do.	17	11,900	20	12,900
Colemanite	do.	90	48,600	87	10,800
Ulexite	do.	149	40,700	120	24,000
Bromine:					
Compounds (contained bromine)	thousand kilograms	18,400	47,800	15,700	55,300
Elemental	do.	850	513	319	194
Cement: Hydraulic and clinker	thousand metric tons	7,060	331,000	(3/)	(3/)
Clays:					
Ball and common blue clay	do.	687	228	836	281
Bentonite	do.	1,990	664	2,050	782
Fire	do.	1,100	282	1,030	464
Fuller's earth and decolorizing earths	do.	101	29	1,440	65
Kaolin (China clay)	do.	7,620	3,460	10,800	4,030
Other (chamotte or dina's earth, artifically activated clay and activated earth)	do.	27,900	12,900	19,400	9,260
Diatomite	metric tons	1,880	338	379	363
Diamonds (industrial):					
Industrial stones [incliding glazer's and engraver's unset, and miner's (natural and synthetic)]	thousand carats	5,200	35,700	2,810	26,400
Powder, dust and grit (natural and synthetic)	do.	133,000	81,100	174,000	89,300
Feldspar	do.	7,050	514	7,360	513
Fluorspar:					
Aluminum fluoride	do.	39,400	31,100	23,700	22,700
Cryolite	do.	3,780	3,070	4,450	3,460
Fluorspar	do.	497,000 r/	46,900 r/	492,000	46,700
Hydrofluoric acid	do.	62,900	60,000	68,200	63,000
Garnet (abrasive)	do.	12,200	XX	6,000	XX

See footnotes at end of table.

TABLE 9 -- Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS -- Continued					
Gemstones (exports and reexports)		XX	$5,850,000	XX	$6,440,000
Graphite:					
Natural	metric tons	52,200	29,900	53,100	26,900
Electric furnace electrodes	do.	34,000	57,800	45,700	95,000
Gypsum:					
Boards	thousand metric tons	171	16,200	370	39,700
Crude	do.	7,390	58,200	8,470	61,400
Plasters	do.	23	1,670	5	960
Other	do.	XX	34,900	XX	39,300
Iodine:					
Crude	metric tons	3,500	27,700	4,260	32,400
Potassium iodide	do.	114	997	134	1,160
Iron oxide pigments:					
Natural	do.	4,840	1,380	6,420	2,140
Synthetic	do.	38,800	55,900	45,000	59,300
Kyanite (andalucite)	do.	12,200	2,130	7,900	1,290
Lime	thousand metric tons	201	13,300	204	13,100
Lithium:					
Carbonate	metric tons	4,290	12,100	4,500	12,700
Hydroxide	do.	24	238	29	330
Magnesium compounds:					
Calcined dolomite	do.	35,800	4,430	(3/)	(3/)
Caustic-calcined magnesia	do.	141,000	15,700	125,000	16,100
Compounds (chlorides, hydroxide, peroxide, and sulfates)	do.	34,000	6,140	55,500	13,700
Dead-burned and fused magnesia	do.	279,000	48,700	342,000	51,800
Magnesite (crude)	do.	332	251	326	133
Other magnesia	do.	51,200	6,270	7,890	8,500
Mica:					
Scrap and flake:					
Powder	do.	13,100	8,070	(3/)	(3/)
Waste	do.	4,770	1,310	(3/)	(3/)
Sheet:					
Unworked	do.	2,960	2,520	(3/)	(3/)
Worked	do.	1,350	9,340	(3/)	(3/)
Nepheline syenite (crushed and ground)	do.	289,000	15,400	333,000	18,700
Nitrogen compounds:					
Anhydrous ammonia	thousand metric tons	3,230	415,000	4,200	725,000
Fertilizer materials	do.	8,270	1,090,000	9,730	1,480,000
Industrial chemicals	do.	51	48,800	54	57,300
Peat moss (poultry and fertilizer grade)	do.	648,000	118,000	669,000	126,000
Perlite (crude)	metric tons	70,000	2,000	70,000	2,100
Phosphate rock and phosphatic materials	thousand metric tons	632	56,000	874	72,300
Potash:					
Potassium chloride	metric tons	7,050,000	549,000	7,790,000	614,000
Potassium nitrate	do.	28,100	7,830	16,400	4,280
Potassium sodium nitrate mixtures	do.	38,900	5,970	45,700	6,180
Potassium sulfate	do.	87,300	15,400	70,900	17,300
Pumice:					
Crude or unmanufactured	thousand metric tons	142	6,430	142	12,000
Wholly or partially manufactured	do.	1	635	1	591
Salt	do.	5,870	100,000	9,630	151,000
Sand and gravel:					
Construction	do.	1,320	15,400	1,500	14,800
Industrial	do.	44	2,440	22	1,790
Sodium compounds:					
Soda ash	do.	89	17,100	79	12,100
Sodium sulfate	do.	163	13,600	190	15,700
Stone:					
Crushed and calcium carbonate fines	thousand metric tons	8,440 r/	74,300	8,940	77,900
Dimension		NA	398,000	NA	(3/)

See footnotes at end of table.

TABLE 9 -- Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS 1/

Mineral		1993		1994	
		Quantity	Value (thousands)	Quantity	Value (thousands)
INDUSTRIAL MINERALS -- Continued					
Strontium:					
Celestite (strontium sulfate)	metric tons	26,400	$1,930	35,500	$2,420
Compounds (carbonate and nitrate)	do.	26,300	15,800	33,200	20,000
Sulfur:					
Elemental	thousand metric tons	2,070 r/	49,800 r/	1,650	62,000
Sulfuric acid (100% H2SO4)	metric tons	2,440,000 r/	70,700 r/	2,130,000	85,100
Talc (unmanufactured)	do.	99,800	10,800	155,000	14,900
Vermiculite	thousand metric tons	30 /e	NA	30 /e	NA
Industrial mineral totals		XX	10,300,000 r/	XX	11,100,000
Total		XX	37,400,000 r/	XX	45,300,000

r/Revised. NA Not available. XX Not applicable.

1/Data rounded by the U.S. Bureau of Mines to three siginificant digits.

2/Less than 1/2 unit.

3/ Data not available at time of table compilation.

TABLE 10
COMPARISON OF WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES

(Metric tons unless otherwise specified)

Mineral		1993			1994		
		World production e/ 1/	U.S. production	U.S. percent of world production	World production e/ 1/	U.S. production	U.S. percent of world production
METALS, MINE BASIS							
Antimony 2/		86,300 r/	W	NA	108,000	W	NA
Arsenic trioxide		41,400 r/	--	--	43,000	--	--
Bauxite 3/	thousand tons	108,000 r/	W	NA	107,000	W	NA
Beryl 4/		6,740 r/	4,940 5/	73	6,130	4,330 5/	71
Chromite	thousand tons	9,300 r/	--	--	9,600	--	--
Cobalt 2/ 4/		20,600 r/	--	--	18,500	--	--
Columbium-tantalum concentrate (gross weight) 6/		29,800 r/	--	--	36,500	--	--
Copper 2/	thousand tons	9,430 r/	1,800	19	9,260	1,810	20
Gold 2/	kilograms	2,310,000 r/	331,000	14	2,290,000	326,000	14
Iron ore (gross weight)	thousand tons	983,000 r/	55,700 r/	6	995,000	58,400	6
Lead 2/	do.	2,830 r/	362	13 r/	2,800	370	13
Manganese ore (gross weight)	do.	21,200 r/	--	--	20,900	--	--
Mercury		2,290 r/	W	NA	1,760	W	NA
Molybdenum 2/		93,600 r/	36,800	39	104,000	46,800	45
Nickel 2/		899,000	2,460 5/	(7/)	NA	NA	NA
Platinum-group metals	kilograms	275,000 r/	8,300 e/	3	250,000	8,400 e/	3
Silver 2/		14,300 r/	1,640 r/	12 r/	13,900	1,480	11
Tin 2/		187,000 r/	W	NA	183,000	--	--
Titanium concentrates (gross weight):							
Ilmenite (including leucoxene)	thousand tons	3,580	W	NA	NA	NA	NA
Rutile	do.	464	W	NA	NA	NA	NA
Tungsten 2/		32,000 r/	W	NA	25,500	W	NA
Vanadium 2/		33,400 r/	2,870	9 r/	33,900	2,740	8
Zinc 2/	thousand tons	6,960 r/	513	7	6,810	598	9
METALS, REFINERY BASIS							
Aluminum	do.	19,700 r/	3,700	19	19,100	3,300	17
Bismuth		4,240 r/	W	NA	4,100	W	NA
Cadmium		18,900 r/	1,090	6	18,100	1,010	6
Cobalt		16,800 r/	--	--	18,500	--	--
Copper (primary and secondary) 8/	thousand tons	11,500 r/	2,250	20	11,200	2,220	20
Lead (primary and secondary) 9/	do.	5,450 r/	1,230 r/	23	5,380	1,260	24
Magnesium (primary)		281,000 r/	132,000	47	267,000	128,000	48
Nickel 10/		807,000	4,880	1	NA	NA	NA
Selenium 6/ 11/	kilograms	1,760,000 r/	283,000	16 r/	1,880,000	360,000	19
Tellurium 4/	do.	89,100 r/	W	NA	93,600	W	NA
Tin 12/		194,000 r/	W	NA	199,000	W	NA
Zinc (primary and secondary)	thousand tons	7,400 r/	382	5	7,360	356	5
IRON AND STEEL							
Direct-reduced iron	do.	23,800 r/	440	2	28,100	480	2
Iron, pig	do.	506,000 r/	48,200	10	512,000	49,400	10
Steel, raw	do.	728,000 r/	88,800	12	726,000	91,200	13
INDUSTRIAL MINERALS							
Asbestos	do.	2,650 r	14 13/	1 r/	2,410	10 13/	(7/)
Barite	do.	4,080 r/	315 13/	8 r/	4,470	758 13/	17
Boron minerals	do.	2,670 r/	1,060 13/	40 r/	2,850	1,110 13/	39
Bromine		396,000 r/	177,000 13/	45	412,000	195,000 13/	47
Cement, hydraulic 14/	thousand tons	1,300,000	72,400 e/	6	NA	NA	NA
Clays:							
Bentonite 4/	do.	7,550 r/	2,870 r/	38 r/	7,580	3,290	43
Fuller's earth 6/	do.	3,660 r/	2,450 13/	67 r/	3,820	2,640 13/	69
Kaolin 4/	do.	25,700 r/	8,830 r/ 13/	34 r/	30,400	8,320 13/	27
Diamond, natural	thousand carats	105,000 r/	--	--	111,000	--	--
Diatomite	thousand tons	1,460 r/	599 13/	41	1,440	613 13/	43
Feldspar	do.	6,390 r/	770	12 r/	6,250	765	12
Fluorspar	do.	3,930 r/	60 e/ 5/	2 r/	3,850	49 e/ 5/	1
Graphite, natural		731,000 r/	--	--	719,000	--	--
Gypsum	thousand tons	99,400 r/	15,800	16 r/	101,000	17,200	17

See footnotes at end of table.

TABLE 10 -- Continued
COMPARISON OF WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES

(Metric tons unless otherwise specified)

Mineral		1993			1994		
		World production e/ 1/	U.S. production	U.S. percent of world production	World production e/ 1/	U.S. production	U.S. percent of world production
INDUSTRIAL MINERALS--Continued							
Iodine, crude		15,700 r/	1,940	12	14,800	1,430	10
Lime 14/	thousand tons	125,000 r/	16,800 r/ 13/	13 r/	118,000	17,400 13/	15
Magnesite, crude	do.	8,310 r/	W	NA	8,520	W	NA
Mica (including scrap and flake) 15/		196,000 r/	87,900	45 r/	214,000	109,000	51
Nitrogen: N content of ammonia	thousand tons	91,700 r/	12,600 r/ 16/	14	91,600	13,400 16/	15
Peat 17/	do.	144,000 r/	616	(7/)	139,000	547	(7/)
Perlite 4/		1,510,000 r/	569,000 13/	38 r/	1,580,000	644,000 13/	41
Phosphate rock (gross weight)	thousand tons	121,000 r/	35,500	29 r/	124,000	41,100	33
Potash (K2O equivalent)	do.	20,300 r/	1,510	7	22,500	1,400	6
Pumice 18/	do.	11,200 r/	469 13/	4	11,400	490 13/	4
Salt 14/	do.	181,000 r/	39,800 r/ e/	22 r/	180,000	39,800 e/	22
Sand and gravel, industrial (silica) 4/	do.	107,000 r/	26,200 13/	25 r/	111,000	27,900 13/	25
Sodium compounds, n.e.s. (natural and namufactured):							
Soda ash 19/	do.	30,500 r/	8,960	29	30,400	9,320	31
Sulfate	do.	4,000 r/	537 r/	13 r/	3,860	463	12
Strontium 4/		156,000 r/	--	--	150,000	--	--
Sulfur, all forms	thousand tons	48,900 r/	11,000	22 r/	51,000	11,500	23
Talc and pyrophyllite 20/	do.	8,340 r/	968	12 r/	7,880	935	12
Vermiculite		494,000 r/	190,000 13/	38 r/	486,000	177,000 13/	37

e/ Estimated. r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

1/ The world production totals on commodities for which U.S. data are withheld exclude U.S. production; therefore percent of world production cannot be reported.

2/ Content of ore and concentrate.

3/ U.S. figures represent dried bauxite equivalent of crude ore; to the extent possible, individual country figures that are included in the world total are also on the dried bauxite basis, but for some countries available data are insufficent to permit this adjustment.

4/ World total does not include an estimate for output in China.

5/ Shipments.

6/ World total does not include estimates for output in the former U.S.S.R. or China.

7/ Less than 1/2 unit.

8/ Includes total production of refined copper, whether produced by pyrometallurgical or electrolytic refining methods and whether derived from primary unrefined copper or from scrap. Copper cathode derived from electrowinning processing is also included.

9/ Includes bullion.

10/ Refined nickel plus nickel content of ferronickel, nickel oxide, and other nickel salts.

11/ U.S. production includes semi-refined selenium exported for further refining.

12/ Includes tin content of alloys made directly from ore.

13/ Quantity sold or used by producers.

14/ Data for the United States include Puerto Rico.

15/ Excludes U.S. production of low-quality sericite and sheet mica, if any.

16/ Synthetic anhydrous ammonia; excludes coke oven byproduct ammonia.

17/ Data for the United States exclude proprietary amounts of fuel peat.

18/ World total does not include an estimate for output in the former U.S.S.R.

19/ U.S. production is natural only.

20/ Data for the United States exclude proprietary pyrophyllite production.

MINING AND QUARRYING TRENDS

By Jean K. Moore

The mining and quarrying trends data shown in this report were reported to the U.S. Bureau of Mines (USBM) by nonfuel mining and quarrying companies operating in the United States. The data for 1994 were reported on the Mine Information Supplement statistical survey conducted by the USBM. Additional data for 1994 were derived from 58 annual USBM production and consumption surveys of minerals producers. These surveys covered 59 nonfuel mineral commodities produced in the United States.

Mining and quarrying data for 1994, as shown in this report, include the annual data for both the construction sand and gravel commodities and the data for the commodities of crushed and dimension stone. These mineral commodities were previously surveyed biennually and appeared alternately in this report. The inclusion of both of the above mentioned sets of data in this report results in essentially a complete coverage of nonfuel minerals production in the United States. This change, however, does not make comparisons of 1994 data with previously reported annual data possible.

Domestic mining of nonfuel mineral materials totaled 4.9 billion metric tons in 1994, including 3.2 billion tons of crude ore mined or quarried and 1.7 billion tons of mine waste and ore from development. Of the nonfuel mineral materials mined, 57% was for the production of industrial minerals and 43% was for the production of metals. Overall, 97% of nonfuel mineral mining and quarrying was surface and the remaining 3% was underground.

Surface mining and quarrying for industrial minerals totaled 2.7 billion tons, of which 2.3 billion tons was crude ore mined and the remainder was waste and ore from development. Underground mining for industrial minerals was minor, amounting to 98 million tons, practically all of which was crude ore.

Surface mining for metal ores totaled 2.1 billion tons, of which about 806 million tons amounted to crude ore mined, while the remaining 1.3 billion tons was waste and ore from development. Underground mining of metal ores was small, amounting to 38 million tons, almost all of which was crude ore.

The major States in which mining for nonfuel minerals occurred were Nevada, Florida, California, Arizona and Minnesota. These States accounted for almost one-half of the mining conducted in the United States. Virtually all of the mining in these five States was surface mining.

TABLE 1
MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES 1/, BY TYPE

(Million metric tons)

Type and year	Surface 2/			Underground 3/			All mines		
	Crude ore	Waste 4/	Total	Crude ore	Waste 4/	Total	Crude ore	Waste 4/	Total
Metals:									
1990	771 r/	1,150 r/	1,920 r/	54	4	57	825 r/	1,150 r/	1,980
1991	854 r/	1,200 r/	2,050	65 r/	2	67 r/	919 r/	1,200 r/	2,120
1992	921 r/	1,110 r/	2,030 r/	37	2	38	957 r/	1,110 r/	2,070 r/
1993	921	1,140	2,060	34	2	36	955	1,140	2,100
1994	806	1,280	2,080	37	1	38	843	1,280	2,120
Industrial minerals:									
1990 5/	1,090	93	1,180	43	(6/)	44	1,130	94	1,230
1991 7/	1,210	132	1,340	62	(6/)	62	1,270	132	1,400
1992 5/	996	267	1,260	36	(6/)	37	1,030	267	1,300
1993	1,180	310	1,490	93	(6/)	94	1,280	311	1,590
1994	2,280	425	2,710	98	(6/)	98	2,380	425	2,800
All mineral commodities:									
1990	1,860 r/	1,240 r/	3,100 r/	97	4	101	1,960 r/	1,250 r/	3,200 r/
1991	2,080 r/	1,330 r/	3,410 r/	129 r/	2	131 r/	2,210 r/	1,330 r/	3,540 r/
1992	1,920 r/	1,380 r/	3,290 r/	73	2	75	1,990	1,380 r/	3,370 r/
1993	2,110	1,450	3,550	127	2	129	2,230	1,450	3,680
1994	3,090	1,700	4,790	135	1	136	3,220	1,700	4,920

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes materials from wells, ponds, and pumping operations.

3/ Includes solution mining.

4/ Includes ore and waste from development operations.

5/ Crushed and broken and dimension stone data were not available because of biennial canvassing.

6/ Less than 1/2 unit.

7/ Construction sand and gravel data were not available because of biennial canvassing.

TABLE 2

MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 1994, BY COMMODITY AND STATE 1/

(Thousand metric tons)

	Surface 2/			Underground 3/			All mines		
	Crude ore	Waste 4/	Total	Crude ore	Waste 4/	Total	Crude ore	Waste 4/	Total
METALS									
Copper	309,000	226,000	535,000	W	W	W	309,000	226,000	535,000
Gold	271,000	793,000	1,060,000	3,090	314	3,400	274,000	794,000	1,070,000
Iron	191,000	124,000	315,000	W	W	W	191,000	124,000	315,000
Lead	--	--	--	4,290	--	4,290	4,290	--	4,290
Zinc	--	--	--	6,360	211	6,570	6,360	211	6,570
Other 5/	35,000	133,000	168,000	23,400	220	23,600	58,400	133,000	192,000
Total	806,000	1,280,000	2,080,000	37,100	745	37,900	843,000	1,280,000	2,120,000
INDUSTRIAL MINERALS									
Barite	1,080	735	1,820	--	--	--	1,080	735	1,820
Bromine	257	--	257	--	--	--	257	--	257
Clays	41,500	36,100	77,600	W	W	W	41,500	36,100	77,600
Diatomite	1,460	W	1,460	--	--	--	1,460	W	1,460
Feldspar 6/	662	--	662	--	--	--	662	--	662
Gypsum	14,300	W	14,300	2,810	4	2,810	17,100	4	17,100
Magnesite	87	--	87	--	--	--	87	--	87
Magnesium compounds	1,400	W	1,400	--	--	--	1,400	W	1,400
Mica (scrap)	83	--	83	--	--	--	83	--	83
Phosphate rock	157,000	W	157,000	--	--	--	157,000	W	157,000
Potash	W	--	W	6,490	--	6,490	6,490	--	6,490
Pumice 7/	556	W	556	--	--	--	556	W	556
Salt	4,460	--	4,460	30,000	--	30,000	34,400	--	34,400
Sand and gravel:									
Construction	856,000	--	856,000	292	--	292	856,000	--	856,000
Industrial	27,300	--	27,300	--	--	--	27,300	--	27,300
Soda ash	W	--	W	8,400	--	8,400	8,400	--	8,400
Stone:									
Crushed	1,150,000	91,900	1,240,000	48,700	341	49,000	1,200,000	92,200	1,290,000
Dimension	1,150	585	1,730	44	--	44	1,190	585	1,780
Talc and pyrophyllite	750	1,030	1,780	W	--	W	750	1,030	1,780
Tripoli	W	22	22	--	--	--	W	22	22
Other 8/	22,400	294,000	317,000	993	1	994	23,400	294,000	318,000
Total industrial minerals	2,280,000	425,000	2,700,000	97,700	346	98,000	2,380,000	425,000	2,800,000
Grand total	3,090,000	1,700,000	4,790,000	135,000	1,090	136,000	3,220,000	1,700,000	4,920,000
STATES									
Alabama	47,100	4,690	51,800	W	--	W	47,100	4,690	51,800
Alaska	44,100	W	44,100	23	3	26	44,100	3	44,100
Arizona	263,000	W	263,000	W	W	W	263,000	W	263,000
Arkansas	36,100	4,940	41,000	--	--	--	36,100	4,940	41,000
California	184,000	106,000	290,000	573	W	573	185,000	106,000	291,000
Colorado	39,800	8,620	48,400	W	W	W	39,800	8,620	48,400
Connecticut	10,800	529	11,400	--	--	--	10,800	529	11,400
Delaware	1,810	--	1,810	--	--	--	1,810	--	1,810
Florida	231,000	378,000	609,000	W	W	W	231,000	378,000	609,000
Georgia	67,600	13,000	80,600	W	W	W	67,600	13,000	80,600
Hawaii	8,650	653	9,300	--	--	--	8,650	653	9,300
Idaho	37,000	15,000	52,000	W	119	119	37,000	15,100	52,200
Illinois	100,000	5,410	106,000	4,910	33	4,940	105,000	5,440	111,000
Indiana	69,600	4,200	73,800	3,840	W	3,840	73,500	4,200	77,700
Iowa	44,800	4,710	49,500	6,900	42	6,950	51,700	4,750	56,500
Kansas	32,600	2,140	34,700	3,160	6	3,160	35,700	2,150	37,900
Kentucky	53,600	4,280	57,800	12,400	87	12,500	66,000	4,370	70,400
Louisiana	17,000	436	17,400	13,500	--	13,500	30,500	436	31,000
Maine	8,490	242	8,740	--	--	--	8,490	242	8,740
Maryland	32,800	2,150	34,900	W	W	W	32,800	2,150	34,900
Massachusetts	22,400	889	23,300	W	W	W	22,400	889	23,300
Michigan	131,000	60,400	191,000	W	4	W	131,000	60,400	191,000
Minnesota	188,000	68,200	256,000	--	--	--	188,000	68,200	256,000
Mississippi	15,300	1,210	16,500	--	--	--	15,300	1,210	16,500
Missouri	73,400	6,500	79,900	11,700	53	11,700	85,100	6,550	91,600
Montana	46,300	66,200	113,000	802	W	802	47,100	66,200	113,000

See footnotes at end of table.

TABLE 2--Continued
MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 1994, BY COMMODITY AND STATE 1/

(Thousand metric tons)

	Surface 2/			Underground 3/			All mines		
	Crude ore	Waste 4/	Total	Crude ore	Waste 4/	Total	Crude ore	Waste 4/	Total
STATES--Continued									
Nebraska	19,700	588	20,300	W	W	W	19,700	588	20,300
Nevada	203,000	712,000	915,000	W	W	W	203,000	712,000	915,000
New Hampshire	8,340	113	8,450	--	--	--	8,340	113	8,450
New Jersey	33,300	1,390	34,700	--	--	--	33,300	1,390	34,700
New Mexico	40,200	W	40,200	7,130	W	7,130	47,400	W	47,400
New York	66,700	4,210	70,900	6,170	--	6,170	72,900	4,210	77,100
North Carolina	81,300	10,500	91,800	--	--	--	81,300	10,500	91,800
North Dakota	6,240	W	6,240	--	--	--	6,240	W	6,240
Ohio	105,000	6,200	111,000	W	--	W	105,000	6,200	111,000
Oklahoma	42,200	3,280	45,400	W	W	W	42,200	3,280	45,400
Oregon	35,800	1,740	37,600	W	--	W	35,800	1,740	37,600
Pennsylvania	87,100	6,280	93,400	2,450	17	2,460	89,500	6,300	95,800
Rhode Island	3,990	129	4,120	--	--	--	3,990	129	4,120
South Carolina	37,900	8,980	46,900	W	W	W	37,900	8,980	46,900
South Dakota	19,200	W	19,200	W	W	W	19,200	W	19,200
Tennessee	53,700	4,640	58,300	8,520	W	8,700	62,200	4,640	66,800
Texas	130,000	8,660	139,000	8,480	W	8,480	138,000	8,660	147,000
Utah	96,400	W	96,400	227	W	227	96,700	W	96,700
Vermont	7,630	319	7,950	W	--	W	7,630	319	7,950
Virginia	65,100	5,240	70,300	W	W	W	65,100	5,240	70,300
Washington	55,100	1,440	56,500	925	W	925	56,000	1,440	57,400
West Virginia	14,400	1,120	15,500	2,720	19	2,730	17,100	1,140	18,300
Wisconsin	56,300	5,000	61,300	--	--	--	56,300	5,000	61,300
Wyoming	11,000	2,620	13,700	8,400	--	8,400	19,500	2,620	22,100
Undistributed 9/	--	157,000	157,000	32,000	708	32,500	32,000	158,000	190,000
Grand total	3,090,000	1,700,000	4,790,000	135,000	1,090	136,000	3,220,000	1,700,000	4,920,000

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Undistributed."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes materials from wells, ponds, and pumping operations.

3/ Includes solution mining.

4/ Includes ore and waste from development operations.

5/ Includes bauxite, beryllium concentrate, gold-silver ore, lead-zinc ore, magnesium metal, manganiferous ore, molybdenum, platinum-group metals, rare earths, silver, titanium, tungsten, uranium, and metal items indicated by symbol W.

6/ Includes aplite.

7/ Excludes volcanic cinder and scoria, included with crushed and broken stone.

8/ Includes abrasives, boron minerals, emery, fluorspar, garnet, greensand marl, iodine, iron oxide pigments, kyanite, lithium minerals, olivine, perlite, sodium sulfate, sulfur (Frasch), vermiculite, wollastonite, zeolites, and industrial mineral items indicated by symbol W.

9/ Includes State items indicated by symbol W.

TABLE 3
VALUE OF PRINCIPAL MINERAL PRODUCTS AND BYPRODUCTS OF SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 1994 1/

(Dollars per metric ton)

	Surface			Underground			All mines		
	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total
METALS									
Copper	13.01	1.53	14.54	W	W	W	13.01	1.53	14.54
Gold	13.04	.42	13.46	70.56	1.21	71.76	13.69	.43	14.11
Iron ore (usable)	8.19	--	8.19	W	W	W	8.19	W	8.19
Lead	--	--	--	46.13	14.69	60.82	46.13	14.69	60.82
Zinc	--	--	--	36.05	W	37.62	36.05	W	37.62
Average, metals 2/	11.69	1.33	13.02	34.18	4.71	38.88	12.69	1.48	14.17
INDUSTRIAL MINERALS									
Barite	20.07	--	20.07	--	--	--	20.07	--	20.07
Clays	38.30	--	38.30	W	W	W	38.30	--	38.30
Feldspar 3/	40.96	W	42.78	--	--	--	40.96	W	42.78
Gypsum (crude)	6.70	--	6.70	6.69	--	6.69	6.70	--	6.70
Magnesium compounds	104.53	--	104.53	--	--	--	104.53	--	104.53
Mica (scrap)	65.97	W	76.60	--	--	--	65.97	W	76.60
Phosphate rock	5.29	W	5.36	--	--	--	5.29	W	5.36
Potash	W	W	W	18.19	--	18.19	18.19	W	18.19
Pumice 4/	24.08	--	24.08	--	--	--	24.08	--	24.08
Salt	74.24	--	74.24	19.93	W	19.93	27.05	W	27.05
Sand and gravel:									
Construction	4.19	.01	4.20	2.81	--	2.81	4.19	.01	4.19
Industrial	17.81	.06	17.87	--	--	--	17.81	.06	17.87
Soda ash	W	W	W	76.71	--	76.71	76.71	W	76.71
Stone:									
Crushed	5.33	--	5.33	7.34	--	7.34	5.41	--	5.41
Dimension	170.43	6.06	176.50	333.56	--	333.56	176.48	5.84	182.32
Talc and pyrophyllite	31.83	W	31.83	W	W	W	31.83	W	31.83
Average, industrial minerals 2/	6.43	.06	6.49	18.45	.10	18.55	6.91	.06	6.97
Average, industrial minerals 2/ (excluding sand and gravel and stone)	18.11	.49	18.60	29.37	.19	29.56	20.00	.44	20.44
Average, metals and industrial minerals 2/	7.81	.39	8.19	22.99	1.39	24.38	8.43	.43	8.86
Average, metals and industrial minerals 2/ (excluding sand and gravel and stone)	13.26	1.15	14.41	31.67	2.18	33.85	14.66	1.23	15.89

W Withheld to avoid disclosing company proprietary data; included in appropriate "Average."

1/ Values calculated from unrounded data; may not add to totals shown because of independent rounding.

2/ Includes unpublished data.

3/ Includes aplite.

4/ Excludes volcanic cinder and scoria; included with crushed and broken stone.

TABLE 4
NUMBER OF DOMESTIC METAL AND INDUSTRIAL MINERAL MINES IN THE UNITED STATES IN 1994, BY COMMODITY AND STATE 1/ 2/

Commodity	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
METAL ORE							
Bauxite	6	--	--	6	--	--	--
Beryllium concentrate	1	--	--	1	--	--	--
Copper	23	--	1	--	5	7	10
Gold	92	6	6	10	25	38	9
Gold-silver	3	--	--	--	--	3	--
Iron	14	--	1	2	2	3	7
Lead	9	--	--	1	7	1	--
Lead-zinc	2	--	--	--	1	1	--
Magnesium metal	3	--	--	1	--	--	2
Manganiferous	1	--	1	--	--	--	--
Molybdenum	2	--	--	--	--	2	--
Platinum-group metals	1	--	--	--	1	--	--
Rare earth metal concentrates	1	--	--	--	1	--	--
Silver	2	--	--	1	--	1	--
Titanium	4	--	1	--	2	--	1
Tungsten	1	1	--	--	--	--	--
Uranium	5	5	--	--	--	--	--
Zinc	11	--	--	--	9	2	--
Total metal ores	180	12	10	21	53	58	29
INDUSTRIAL MINERAL							
Abrasives	10	9	--	1	--	--	--
Barite	9	--	3	1	5	--	--
Boron minerals	4	--	1	--	2	1	--
Bromine	6	--	--	6	--	--	--
Clays	710	38	125	427	120	--	--
Diatomite	11	1	--	6	4	--	--
Emery	1	1	--	--	--	--	--
Feldspar 3/	10	--	1	6	3	--	--
Fluorspar	1	--	--	--	1	--	--
Garnet	2	--	--	2	--	--	--
Greensand marl	1	--	1	--	--	--	--
Gypsum	59	--	2	13	44	--	--
Iodine	3	3	--	--	--	--	--
Iron oxide pigments (crude)	3	2	--	1	--	--	--
Kyanite	2	--	--	2	--	--	--
Lithium minerals	3	1	1	1	--	--	--
Magnesite	1	--	--	1	--	--	--
Magnesium compounds	5	--	1	1	3	--	--
Mica (scrap)	7	--	3	4	--	--	--
Olivine	3	--	--	3	--	--	--
Perlite	8	--	3	2	3	--	--
Phosphate rock	17	--	--	--	--	9	8
Potash	9	--	--	3	1	5	--
Pumice 4/	14	--	3	10	1	--	--
Salt	63	--	3	14	35	12	--
Sand and gravel:							
Construction	7,370	240	1,680	3,390	1,980	80	--
Industrial	167	1	11	82	72	1	--
Sodium compounds:							
Soda ash	6	--	--	--	--	6	--
Sodium sulfate	1	--	--	--	1	--	--
Stone:							
Crushed	3,640	219	516	991	1,630	288	--
Dimension	248	74	143	31	--	--	--
Sulfur (Frasch)	2	--	--	--	1	1	--
Talc and pyrophyllite	23	4	6	8	5	--	--
Tripoli	6	2	1	3	--	--	--
Vermiculite	4	--	--	3	1	--	--
Wollastonite	2	--	--	2	--	--	--
Zeolites	6	3	1	2	--	--	--
Total industrial minerals	12,400	598	2,510	5,020	3,910	403	8
Grand total	12,600	610	2,520	5,040	3,960	461	37

See footnotes at end of table.

TABLE 4--Continued
NUMBER OF DOMESTIC METAL AND INDUSTRIAL MINERAL MINES IN THE UNITED STATES IN 1994, BY COMMODITY AND STATE 1/ 2/

Commodity	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
STATE							
Alabama	171	2	18	70	67	14	--
Alaska	67	4	13	20	24	6	1
Arizona	223	5	26	93	81	11	7
Arkansas	165	8	23	75	50	9	--
California	725	35	208	219	223	40	1
Colorado	389	5	81	219	77	7	--
Connecticut	74	2	9	29	34	--	--
Delaware	9	1	1	1	6	--	--
Florida	179	--	--	52	99	20	8
Georgia	258	5	41	98	93	21	--
Hawaii	43	2	8	20	11	2	--
Idaho	264	9	43	157	47	8	--
Illinois	328	5	21	115	161	26	--
Indiana	246	--	25	77	130	14	--
Iowa	371	4	32	204	127	4	--
Kansas	347	32	68	146	98	3	--
Kentucky	134	--	10	24	86	14	--
Louisiana	113	4	4	48	50	7	--
Maine	190	8	77	83	22	--	--
Maryland	101	5	14	37	35	10	--
Massachusetts	133	5	12	47	65	4	--
Michigan	542	14	113	268	132	14	2
Minnesota	517	22	107	275	103	5	5
Mississippi	110	2	12	58	36	2	--
Missouri	376	8	65	116	171	16	--
Montana	207	10	74	83	33	6	1
Nebraska	262	43	35	142	39	3	--
Nevada	396	10	234	54	72	19	7
New Hampshire	71	1	7	34	29	--	--
New Jersey	97	--	6	32	52	7	--
New Mexico	190	10	35	95	42	7	1
New York	624	41	185	237	154	7	--
North Carolina	279	12	40	117	95	14	1
North Dakota	95	1	19	60	15	--	--
Ohio	383	6	29	113	214	21	--
Oklahoma	167	13	18	61	66	9	--
Oregon	613	143	258	126	81	5	--
Pennsylvania	353	18	30	117	178	10	--
Rhode Island	23	--	2	9	12	--	--
South Carolina	145	5	13	67	54	6	--
South Dakota	213	2	77	106	22	6	--
Tennessee	192	1	14	49	118	10	--
Texas	511	37	52	177	223	21	1
Utah	222	14	52	84	66	6	1
Vermont	152	13	34	84	21	--	--
Virginia	201	8	19	66	93	15	--
Washington	441	12	107	189	126	6	1
West Virginia	52	1	2	18	28	3	--
Wisconsin	558	9	106	302	136	5	--
Wyoming	97	6	16	43	26	6	--
Grand total	12,600	610	2,520	5,040	3,960	461	37

1/ Based on crude ore mined.

2/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes aplite.

4/ Excludes volcanic cinder and scoria; included with crushed stone.

TABLE 5
TWENTY-FIVE LEADING METAL AND INDUSTRIAL MINERAL MINING OPERATIONS IN THE UNITED STATES IN 1994, IN ORDER OF OUTPUT OF CRUDE ORE

Mining operation 1/	State	Operator	Commodity	Mining method
METALS				
Carlin Mines Complex	Nevada	Newmont Gold Co.	Gold	Open pit.
Bingham Canyon	Utah	Kenneoott, Utah Copper Corp.	Copper	Do.
Minntac	Minnesota	USX	Iron ore	Do.
Sierrita	Arizona	Cyprus Climax Metals Co.	Copper	Do.
Morenci	do.	Phelps Dodge Corp.	do.	Do.
Bagdad	do.	Cyprus Climax Metals Co.	do.	Do.
Hibbing	Minnesota	Hibbing Taconite Co.	Iron ore	Do.
Cyprus Miami (Inspiration)	Arizona	Cyprus Climax Metals Co.	Copper	Do.
Hoyt Lakes	Minnesota	LTV Steel Mining Co.	Iron ore	Do.
Empire	Michigan	Empire Iron Mining Partnership	do.	Do.
Smokey Valley Common Operation	Nevada	Round Mountain Gold Corp.	Gold	Do.
Pinto Valley	Arizona	Magma Copper Co.	Copper	Do.
Ray	do.	ASARCO Incorporated	do.	Do.
San Manuel	do.	Magma Copper Co.	do.	Open pit and stoping.
Chino	New Mexico	Phelps Dodge Corp.	do.	Open pit.
Thunderbird	Minnesota	Eveleth Mines	Iron ore	Do.
Twin Creeks	Nevada	Santa Fe Pacific Gold Corp.	Gold	Do.
Continental	Montana	Montana Resources Inc.	Copper	Do.
Zortman-Landusky	do.	Pegasus Gold Inc.	Gold	Do.
Mission Complex	Arizona	ASARCO Incorporated	Copper	Do.
Green Cove	Florida	RGC (USA) Mineral Sands, Inc .	Titanium	Dredging.
Mesquite	California	Santa Fe Pacific Gold Corp.	Gold	Open pit.
Tilden	Michigan	Tilden Mining Co.	do.	Do.
Peter Mitchell	Minnesota	Cyprus Climax Metals Co.	Iron ore	Do.
McCoy and Cove	Nevada	Echo Bay Mining Co.	Gold	Open pit and stoping.
INDUSTRIAL MINERALS				
Florida mines (6)	Florida	IMC-Agrico Co.	Phosphate rock	Open pit.
Fort Meade	do.	Cargill Fertilizer Inc.	do.	Do.
Lee Creek (Aurora)	North Carolina	Texasgulf Chemical Co.	do.	Do.
All Alaska operations	Alaska	U.S. Bureau of Land Management	Sand and gravel	Open quarry.
Reed	Kentucky	Vulcan Materials Co.	Stone	Do.
Florida mines (2)	Florida	Mobil Mining & Mineral Co.	Phosphate rock	Open pit.
FEC Hialea	do.	CSR America Inc.	Stone	Open quarry.
Georgetown	Texas	Texas Crushed Stone Co.	do.	Do.
Beckmann	do.	Redland Stone Products Co.	do.	Do.
Pennsuco	Florida	Tarmac America Inc.	do.	Dredging.
Calcite	Michigan	Michigan Minerals Associates	do.	Open quarry.
Stoneport	do.	Presque Isle Corp.	do.	Do.
McCook	Illinois	Vulcan Materials Co.	do.	Do.
White Rock	Florida	Vecellio & Grogan Inc.	do.	Dredging.
International	New Mexico	IMC Fertilizers Inc.	Potash	Well or pumping operation.
Thornton	Illinois	General Dynamics Corp., Material Service Corp.	Stone	Open quarry and stoping.
St. Genevieve	Missouri	Tower Rock Stone Co.	do.	Open quarry.
Norcross	Georgia	Vulcan Materials Co.	do.	Do.
Cave-in-Rock	Illinois	Dravo Basic Materials	do.	Do.
Sheldon/Peoria	California	Calmat Co., Inc.	Sand and gravel	Do.
Richards	Oklahoma	Dolese Bros.Co.	Stone	Do.
Cape Sandy	Indiana	Mulzer Crushed Stone Co., Inc.	do.	Do.
Permanente	California	Cornerstone Construction & Materials, Inc.	do.	Do.
Millville	West Virginia	Evered Bardon USA Inc. (Millville Quarry Inc.)	do.	Do.
Henderson	Nevada	Nevada Ready Mix Co.	Sand and gravel	Do.

1/ Owing to commodity reporting differences, the rank of individual mining operations may not be available.

TABLE 6
TWENTY-FIVE LEADING METAL AND INDUSTRIAL MINERAL MINING OPERATIONS IN THE UNITED STATES IN 1994, IN ORDER OF OUTPUT OF TOTAL MATERIALS HANDLED

Mining operation 1/	State	Operator	Commodity	Mining method
METALS				
Carlin Complex	Nevada	Newmont Gold Co.	Gold	Open pit.
Goldstrike	do.	Barrick Goldstrike Mines Inc.	do.	Do.
Bingham Canyon	Utah	Kennecott Corp.	Copper	Do.
Trail Ridge	Florida	E. I. du Pont de Nemours & Co., Inc.	Titanium	Dredging.
Chino	New Mexico	Chino Mines Co.	Copper	Open pit.
Twin Creeks	Nevada	Santa Fe Pacific Gold Corp.	Gold	Do.
Cyprus Miami (Inspiration)	Arizona	Cyprus Climax Metals Co.	Copper	Do.
Sierrita	do.	do.	do.	Do.
McCoy and Cove	Nevada	Echo Bay Mining Co.	Gold	Do.
Empire	Michigan	Empire Iron Mining Partnership	Iron ore	Do.
Hoyt Lakes	Minnesota	LTV Steel Mining Co.	do.	Do.
Hibbing	do.	Pickands Mather & Co.	do.	Do.
Smokey Valley Common Operation	Nevada	Round Mountain Gold Corp.	Gold	Do.
Mesquite	California	Santa Fe Pacific Gold Corp.	do.	Do.
Minntac	Minnesota	USX	Iron ore	Do.
Morenci	Arizona	Phelps Dodge Corp.	Copper	Do.
Bagdad	do.	Cyprus Climax Metals Co.	do.	Do.
Lone Tree	Nevada	Santa Fe Pacific Gold Corp.	Gold	Do.
Crofoot/Lewis	do.	Hycroft Resources & Development	do.	Do.
Zortman- Landusky	Montana	Pegasus Gold Corp.	do.	Do.
Jerritt Canyon (Enfield Bell)	Nevada	Independence Mining Co. Inc.	do.	Do.
Continental	Montana	Montana Resources Inc.	Copper	Do.
Montana Tunnels	do.	Montana Tunnels Mining, Inc.	Gold	Do.
Thunderbird	Minnesota	Eveleth Mines	Iron ore	Do.
Getchell	Nevada	FMG Inc.	Gold	Do.
INDUSTRIAL MINERALS				
Florida Mines (6)	Florida	IMC-Agrico Co.	Phosphate rock	Open pit.
Fort Meade	do.	Cargill Fertilizer Inc.	do.	Do.
Big Four	do.	Mobil Mining & Minerals Co.	do.	Do.
Lee Creek (Aurora)	North Carolina	Texasgulf Inc.	do.	Do.
Boron	California	U.S. Borax & Chemical Co.	Boron minerals	Do.
All Alaska operations	Alaska	U.S. Bureau of Land Management	Sand and gravel	Open quarry.
Reed	Kentucky	Vulcan Materials Co.	Stone	Do.
Rockland	Florida	U.S. Agri-Chemicals Corp.	Phosphate rock	Open pit.
FEC Hialea	do.	CSR America Inc.	Stone	Open quarry.
Georgetown	Texas	Texas Crushed Stone Co.	do.	Do.
Beckmann	do.	Redland Stone Products Co.	do.	Do.
Pennsuco	Florida	Tarmac America Inc.	do.	Dredging.
Calcite	Michigan	Michigan Minerals Associates	do.	Open quarry.
Stoneport	do.	Presque Isle Corp.	do.	Do.
McCook	Illinois	Vulcan Materials Co.	do.	Do.
White Rock	Florida	Vecellio & Grogan Inc.	do.	Dredging.
International	New Mexico	IMC Fertilizer Inc.	Potash	Well and pumping operation.
Thornton	Illinois	General Dynamics Corp, Material Service Corp.	Stone	Open quarry.
Carey Limestone	Missouri	Tower Rock Stone Co.	do.	Do.
Conda Smokey	Idaho	J. R. Simplot Co., Minerals & Chemicals Group	Phosphate rock	Open pit.
Norcross	Georgia	Vulcan Materials Co.	Stone	Open quarry.
Cave-in-Rock	Illinois	Dravo Basic Materials	do.	Do.
Richards	Oklahoma	Dolese Bros Co.	do.	Do.
Cape Sandy	Indiana	Mulzer Crushed Stone Co. Inc.	do.	Do.
Permanente	California	Cornerstone Construction & Materials Inc.	do.	Do.

1/ Owing to commodity reporting differences, the rank of individual mining operations may not be available.

TABLE 7

MARKETABLE PRODUCT AND ORE TREATED OR SOLD AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 1994, BY COMMODITY AND STATE 1/

(Thousand metric tons)

	Marketable product			Ore treated or sold		
	Surface	Underground	Total	Surface	Underground	Total
METALS						
Copper	1,360	W	1,360	299,000	W	299,000
Gold	W	W	W	225,000	1,970	227,000
Iron ore (usable)	57,300	W	57,300	191,000	W	191,000
Lead	--	W	W	--	1,030	1,030
Manganiferous ore (5% to 35% Mn)	3	--	3	W	--	W
INDUSTRIAL MINERALS						
Asbestos	10	--	10	W	--	W
Barite	582	--	582	1,080	--	1,080
Bromine	W	--	W	257	--	257
Clays	41,400	W	41,400	41,400	W	41,400
Diatomite	613	--	613	W	--	W
Feldspar 2/	662	--	662	662	--	662
Gypsum (crude)	14,300	2,810	17,200	14,300	2,810	17,200
Magnesite	87	--	87	87	--	87
Magnesium compounds	390	--	390	1,330	--	1,330
Mica (scrap)	83	--	83	83	--	83
Perlite	W	3	3	W	3	3
Phosphate rock	41,100	--	41,100	159,000	--	159,000
Potash	W	1,440	1,440	W	6,490	6,490
Pumice 3/	490	--	490	490	--	490
Salt	4,260	30,100	34,400	4,530	30,000	34,500
Sand and gravel:						
Construction	891,000	292	891,000	891,000	292	891,000
Industrial	27,300	--	27,300	27,300	--	27,300
Soda ash	W	8,400	8,400	W	8,400	8,400
Stone:						
Crushed	1,170,000	57,800	1,230,000	1,180,000	48,700	1,230,000
Dimension	1,150	44	1,190	1,150	44	1,190
Talc and pyrophyllite	746	W	746	746	W	746
Vermiculite (crude)	177	--	177	W	--	W
STATES						
Alabama	48,100	W	48,100	48,200	W	48,200
Alaska	19,900	--	19,900	36,200	--	36,200
Arizona	41,500	288	41,800	263,000	W	263,000
Arkansas	36,200	--	36,200	36,200	--	36,200
California	146,000	W	146,000	173,000	576	174,000
Colorado	38,400	111	38,500	41,100	W	41,100
Connecticut	11,200	--	11,200	11,200	--	11,200
Delaware	2,580	--	2,580	2,580	--	2,580
Florida	114,000	W	114,000	229,000	W	229,000
Georgia	67,300	W	67,300	67,800	W	67,800
Hawaii	8,690	--	8,690	8,690	--	8,690
Idaho	25,500	W	25,500	38,100	258	38,400
Illinois	99,800	7,550	107,000	103,000	4,910	107,000
Indiana	70,300	W	70,300	72,400	3,840	76,200
Iowa	47,900	6,900	54,800	47,900	6,900	54,800
Kansas	33,800	3,160	36,900	33,800	3,160	36,900
Kentucky	51,500	14,800	66,300	53,900	12,400	66,300
Louisiana	17,100	13,600	30,700	17,200	13,500	30,700
Maine	8,660	--	8,660	8,660	--	8,660
Maryland	32,800	W	32,800	32,800	W	32,800
Massachusetts	22,700	W	22,700	22,800	W	22,800
Michigan	103,000	1,210	105,000	133,000	W	133,000
Minnesota	84,800	--	84,800	189,000	--	189,000
Mississippi	15,600	--	15,600	15,600	--	15,600
Missouri	73,400	W	73,400	74,500	9,820	84,300
Montana	10,300	239	10,500	46,400	802	47,200
Nebraska	20,300	W	20,300	20,300	W	20,300
Nevada	28,000	3	28,000	217,000	W	217,000
New Hampshire	8,550	--	8,550	8,550	--	8,550
New Jersey	37,600	--	37,600	37,600	--	37,600

See footnotes at end of table.

TABLE 7--Continued

MARKETABLE PRODUCT AND ORE TREATED OR SOLD AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 1994, BY COMMODITY AND STATE 1/

(Thousand metric tons)

	Marketable product			Ore treated or sold		
	Surface	Underground	Total	Surface	Underground	Total
STATES--Continued						
New Mexico	16,900	1,470	18,300	40,200	7,140	47,300
New York	69,200	5,520	74,700	69,200	6,030	75,200
North Carolina	75,300	--	75,300	82,500	--	82,500
North Dakota	6,880	--	6,880	6,880	--	6,880
Ohio	108,000	W	108,000	108,000	W	108,000
Oklahoma	43,100	W	43,100	43,100	W	43,100
Oregon	37,900	--	37,900	38,200	--	38,200
Pennsylvania	91,500	2,450	93,900	91,500	2,450	93,900
Rhode Island	3,990	--	3,990	3,990	--	3,990
South Carolina	31,600	W	31,600	38,100	W	38,100
South Dakota	13,400	W	13,400	16,200	W	16,200
Tennessee	56,200	W	56,200	56,900	5,920	62,800
Texas	139,000	8,590	148,000	139,000	8,480	148,000
Utah	29,300	W	29,300	93,700	W	93,700
Vermont	8,310	W	8,310	8,310	W	8,310
Virginia	65,100	1,540	66,700	65,300	W	65,300
Washington	55,700	W	55,700	55,700	940	56,700
West Virginia	15,200	2,720	17,900	15,200	2,720	17,900
Wisconsin	59,500	--	59,500	59,900	--	59,900
Wyoming	11,200	8,400	19,600	11,200	8,400	19,600

W Withheld to avoid disclosing company proprietary data.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes aplite.

3/ Excludes volcanic cinder and scoria; included with crushed and broken stone.

TABLE 8
MINING METHODS USED AT SURFACE OPERATIONS IN THE UNITED STATES, BY COMMODITY, IN 1994

(Percent of total material handled)

Commodity	Preceded by drilling and blasting	Not preceded by drilling and blasting 1/
METALS		
Bauxite	--	100
Beryllium concentrate	100	--
Copper	97	3
Gold	95	5
Gold-silver	97	3
Iron	97	3
Lead-zinc	100	--
Magnesium metal	55	45
Manganiferous	--	100
Molybdenum	100	--
Rare earth metal concentrates	100	--
Silver	100	--
Titanium	--	100
Tungsten	--	100
Uranium	--	100
Average	90	10
INDUSTRIAL MINERALS		
Abrasives	100	--
Barite	30	70
Boron minerals	100	--
Bromine	--	100
Clays	--	100
Diatomite	5	95
Emery	100	--
Feldspar 2/	100	--
Garnet	32	68
Greensand marl	--	100
Gypsum	90	10
Iodine	--	100
Iron oxide pigments (crude)	100	--
Kyanite	100	--
Lithium minerals	84	16
Magnesite	100	--
Magnesium compounds	79	21
Mica (scrap)	91	9
Olivine	55	45
Perlite	25	755
Phosphate rock	3	97
Potash	--	100
Pumice 3/	17	83
Salt	2	98
Sand and gravel:		
Construction	--	100
Industrial	--	100
Soda ash	--	100
Stone:		
Crushed	99	1
Dimension	--	100
Sulfur (Frasch)	--	100
Talc and pyrophyllite	87	13
Tripoli	97	3
Vermiculite	3	97
Wollastonite	100	--
Zeolites	100	--
Average	48	52
Average, metals and industrial minerals	66	34

1/ Includes drilling and cutting without blasting, dredging, and mechanical excavation and nonfloat washing, and other surface mining methods.

2/ Includes aplite.

3/ Excludes volcanic cinder and scoria; included with crushed and broken stone.

TABLE 9
TOTAL MATERIAL (ORE AND WASTE) PRODUCED BY MINE DEVELOPMENT AND TOTAL DEVELOPMENT ACTIVITY IN THE UNITED STATES IN 1994, BY COMMODITY AND STATE 1/

	Drifting, crosscutting, or tunneling		Raising		Shaft and winze sinking		Stripping	Other		Total	
	Thousand metric tons	Meters	Thousand metric tons	Meters	Thousand metric tons	Meters	Thousand metric tons	Thousand metric tons	Meters	Thousand metric tons	Meters
COMMODITY											
Gold	W	W	W	W	W	W	34,500	W	W	34,500	W
Iron ore (usable)	W	W	--	--	--	--	W	W	W	W	W
Perlite	--	--	--	--	--	--	1	--	--	1	XX
Silver	(2/)	30	--	--	(2/)	10	--	--	--	(2/)	40
Tripoli	--	--	--	--	--	--	22	--	--	22	XX
Zinc	126	4,840	--	--	--	--	--	--	--	126	4,840
Other 3/	102	3,120	W	W	W	W	5,210	11	482	5,320	3,600
Total	228	7,990	W	W	(2/)	10	39,700	11	482	40,000	8,480
Percent of activity, total	XX	94.2	XX	W	XX	(2/)	XX	XX	5.8	XX	100
STATE											
Alaska	3	198	--	--	--	--	8,640	--	--	8,640	198
California	4	174	W	W	W	W	22,000	--	--	22,000	174
Colorado	--	--	--	--	(2/)	10	W	--	--	(2/)	10
Idaho	68	1,400	--	--	--	--	W	W	--	68	1,400
Minnesota	--	--	--	--	--	--	296	--	--	296	--
Undistributed 4/	153	6,210	W	W	W	W	8,740	11	482	8,900	6,690
Total	228	7,990	W	W	(2/)	10	39,700	11	482	40,000	8,480
Percent of activity, total	XX	94.2	XX	W	XX	(2/)	XX	XX	5.8	XX	100

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Undistributed," "Other" development. XX Not applicable.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Includes diatomite, fluorspar, iron ore, talc and pyrophyllite, and commodity items indicated by symbol W.

4/ Includes Arkansas, Missouri, Montana, Nevada, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, South Carolina, Tennessee, Texas, Washington, Wisconsin, and State items indicated by symbol W.

ALUMINUM

By Patricia A. Plunkert

Domestic primary aluminum production decreased significantly in 1994 to its lowest level in 7 years. Thirteen companies operated 22 primary aluminum reduction plants and 1 plant remained temporarily closed. Montana, Oregon, and Washington accounted for 36% of the production; Kentucky, North Carolina, South Carolina, and Tennessee, 20%; and other States, 44%. The value of primary metal produced domestically in 1994 was estimated at $5.2 billion. In response to continued rising inventories and depressed prices during the first half of the year, the domestic primary aluminum smelters continued to announce temporary shutdowns in production capacity.

Aluminum recovered from purchased scrap, however, increased 5% to approximately 3.1 million metric tons. Fifty-one percent of this recovered metal came from new (manufacturing) scrap and 49% from old scrap (discarded aluminum products). The recycling rate for aluminum used beverage can (UBC) scrap increased to 65.4%.

Aluminum consumption, by an estimated 25,000 firms, was centered in the East Central United States. In quantity, transportation edged out the packaging and container industry as the dominant domestic market for aluminum products in 1994. Transportation and packaging each accounted for an estimated 28% of domestic consumption; building, 17%; electrical and consumer durables, 8% each; and other uses, 11%.

U.S. imports for consumption continued to increase dramatically in 1994. The level of imported ingot from the former U.S.S.R. continued to increase. Total exports also increased in 1994, reversing a 2-year downward trend.

The price of primary aluminum ingot trended upward during the year on the domestic and world markets. Prices in the aluminum scrap markets paralleled the general trend of primary ingot prices.

World inventory levels at the end of the year were mixed. By yearend, inventories on the London Metal Exchange (LME) had decreased by nearly one-third to approximately 1.7 million tons; whereas inventories held by producers, as reported by the International Primary Aluminium Institute (IPAI), showed a slight increase.

Primary aluminum was produced in 43 countries in 1994. The United States was the largest producer with 17% of the world total, followed by Russia with 14%, and Canada with 12%. World metal production decreased 3% compared with that of the previous year. Many of the announced production reductions took effect during the year.

In January, discussions begun in late 1993 among several major aluminum-producing countries culminated in the signing of a Memorandum of Understanding Concerning the Aluminum Market. *(See Legislation and Government Programs.)*

Legislation and Government Programs

Representatives of the authorities of Australia, Canada, the European Union, Norway, the Russian Federation, and the United States met in Brussels in January 1994. Following governmental consultations, these representatives, on January 28, 1994, subscribed to a Memorandum of Understanding (MOU), which recognized that the world aluminum industry was facing a grave, exceptional, and unforeseeable situation involving a considerable excess global supply of primary aluminum. In their assessment, these structural problems were due to an unanticipated combination of political and economic developments, which was unlikely to reoccur. They considered that the principal response to this situation should be by way of worldwide market oriented commercial decisions by companies on an individual basis. In the agreement, the Russian Federation agreed to reduce production of primary aluminum by 500,000 tons per year (to be composed of a first stage decrease of 300,000 tons per year within 3 months of February 1, 1994, and 200,000 tons per year within the following 3 months).

The participants also considered that unilateral trade actions were not the preferred response to the aluminum market problems and that any such actions would be inconsistent with this MOU. The participants considered that the aluminum industry should operate on the basis of fair competition and high environmental standards. With a view to furthering restructuring of the Russian aluminum industry, participants considered that all means should be examined in order to provide technical and other assistance to the Russian Federation to facilitate modernization, the improvement of environmental standards, and the development of internal aluminum consumption. The participants considered that this MOU would apply for 24 months at the maximum.

In a follow-up meeting in Canada in March, the participants to the MOU decided to establish a Working Group of Experts (the Group) to be composed of members representing those governments and authorities to the MOU. The Group's purpose was to provide a forum for the collection, exchange, and review of publicly available and nationally aggregated information, in order to improve the transparency of the aluminum market. In July, at a MOU meeting in Canberra, Australia, the Group released the first set of data from the members on production and trade. These data have continued to be released to the public on a monthly basis. [1]

Production

Primary.—Domestic primary aluminum production, totaling 3,298,504 tons, decreased 11% compared with 1993 production. Production data were obtained by surveying the 13 domestic producers, all of whom responded to the U.S. Bureau of Mines survey.

During the year, several companies announced temporary reductions in primary aluminum metal production capacity. By the end of the year, domestic capacity had been reduced by a total of 1,012,000 tons, 24% of engineered capacity levels.

Ravenswood Aluminum Corp. announced that Marc Rich & Co. AG had acquired full ownership of the West Virginia aluminum smelting and rolling complex.[2] Later in the year, Marc Rich & Co. announced that it was changing its name to Glencore International AG.[3] *(See tables 1 and 2.)*

Secondary.—Metal recovered from both new and old scrap reached an historic high of approximately 3.1 million tons in 1994, according to data derived by the U.S. Bureau of Mines from its "Aluminum Scrap" survey. Of the 95 companies and/or plants to which monthly or annual survey requests were sent, 79 responded, representing 90% of the total scrap consumed shown in table 4.

According to figures released by the Aluminum Association Inc., the Can Manufacturers Institute, and the Institute of Scrap Recycling Industries Inc., a record 64.7 billion aluminum beverage cans were recycled in the United States during 1994. The recycling rate, based on the number of cans shipped during the year, was 65.4%, more than 2% higher than the 1993 recycling rate of 63.1%. According to the organizations' joint-press release, every aluminum beverage can produced in 1994 had an average of 54.1% post-consumer recycled content, a far higher percentage than any other beverage container. *(See tables 3, 4, and 5.)*

Consumption

The container and packaging industry, which had dominated the U.S. aluminum market since the mid-1970's, was no longer dominant in 1994; the transportation industry became the largest consumer of aluminum products. The use of aluminum by the transportation industry, especially the automotive sector, has been growing over the last several years, and, if announcements of new aluminum applications by the automotive industry are any indication of future trends, the growth should continue into the future. *(See tables 6 and 7.)*

Stocks

Inventories of aluminum ingot, mill products, and scrap at reduction and other processing plants, as reported by the U.S. Department of Commerce, increased from a revised 1.98 million tons at yearend 1993 to 2.07 million tons at yearend 1994.

The LME reported that its U.S. warehouses held a total of about 16,500 tons of primary aluminum metal ingot at yearend 1994, a dramatic decrease from the approximately 168,000 tons of metal reportedly held in these warehouses at yearend 1993. The LME also reported that aluminum alloy ingot held at its U.S. warehouses at yearend 1994 increased to 1,100 tons, a slight increase from the 980 tons of alloy held at yearend 1993.

There were no releases of aluminum metal from the National Defense Stockpile during the year, and the inventory level remained at 57,000 tons.

Prices

The monthly average U.S. market price of primary aluminum metal, as reported by Platt's Metals Week, followed a general upward trend throughout the year. The monthly average price began the year at a low of 56.0 cents per pound and posted a high of 92.05 cents per pound in November. The average price for the year was 71.165 cents per pound, a dramatic increase compared with the 1993 average annual price of 53.326 cents per pound. The LME cash price for high-grade primary aluminum ingot followed the same general trend as the U.S. market price. The 1994 average annual LME cash price was 66.986 cents per pound.

Purchase prices for aluminum scrap, as quoted by American Metal Market (AMM), fluctuated during the year and closed the year at significantly higher levels than those at the beginning of the year. The yearend price ranges for selected types of aluminum scrap were as follows: mixed low-copper-content aluminum clips, 69 to 70 cents per pound; old sheet and cast, 63 to 65 cents per pound; and clean, dry aluminum turnings, 64 to 65 cents per pound. Prices for UBC's also trended upward and closed at approximately twice the level of those at the beginning of the year. Aluminum producers' buying price range for processed and delivered UBC's, as quoted by AMM, began the year at 33 to 37 cents per pound. The price range at the end of the year narrowed and increased to 70 to 72 cents per pound.

The yearend indicator prices, as published by AMM, for selected secondary aluminum ingots also increased compared with those of the previous year and were as follows: alloy 380 (1% zinc content), 98.98 cents per pound; alloy 360 (0.6% copper content), 102.79 cents per pound; alloy 413 (0.6% copper content), 102.51 cents per pound; and alloy 319, 102.30 cents per pound. Metals Week published an annual average U.S. price of 74.71 cents per pound for A-380 alloy (3% zinc content). The average annual LME cash price for a similar aluminum 380 alloy was 65.90 cents per pound.

Foreign Trade

Total exports of aluminum from the United States increased in 1994, reversing a downward trend that began in 1992. Although crude metal and alloys exports decreased compared with those of the previous year, exports of semifabricated materials and scrap showed a marked improvement compared with those of 1993.

Imports for consumption (excluding manufactured products) continued to increase dramatically, to a record high approaching 3.4 million tons. Imports in all three subcategories shown in table 11 increased significantly compared with those of the previous year; however, the most dramatic increase, 35%, occurred in the crude metal and alloys category. Shipments from most countries increased from those of the previous year. Canada remained the major shipping country to the United States; however, shipments of aluminum ingot from Russia, Latvia, Tajikistan, and Ukraine continued to increase dramatically. Combined imports from these countries exceeded 700,000 tons, a 60% increase compared with the ingot imports from these countries in 1993. *(See tables 8, 9, 10, and 11.)*

World Review

World production of primary aluminum metal decreased in 1994. During the year, several companies announced temporary cuts in production capacity totaling approximately 1.2 million tons. Increased world economic activity and a reduction in excess world inventory levels, especially those inventories held by the LME, helped to move the supply/demand situation into a more balanced condition. World metal prices began to rise, reversing the trend of the previous year. Large quantities of Russian metal continued to flow onto the world market. However, the world market began to adjust to these increased shipments, and their impact on the market appeared to have lessened.

Primary aluminum inventories held by members of the IPAI, which represent the bulk of stocks held outside the former centrally planned economy countries and the LME, increased from a revised 2.01 million tons at yearend 1993 to 2.06 million tons at yearend 1994. IPAI reported that total metal inventories, including secondary aluminum, held by its members increased from a revised 3.54 million tons at yearend 1993 to 3.58 million tons at yearend 1994.

Inventories of primary aluminum metal held by the LME reached record levels in mid-1994. At the beginning of the year, LME inventories totaled 2.49 million tons. By the end of May, the total had reached 2.66 million tons. Inventories then began to decrease dramatically, and, by the end of the year, close to 1 million tons of excess stocks had been removed from LME warehouses, and the inventory level had dropped to 1.68 million tons. *(See table 12.)*

Outlook

Demand for aluminum in the United States showed signs of slowing during the first quarter of 1995 following the significant growth evident in 1994. It was unclear whether this decrease was a reaction to a general slowing of the U.S. economy or to a work-off of stocks built up in the latter half of 1994 in anticipation of rising aluminum prices. Prices both in the U.S. and world markets appeared to have stabilized in the first quarter of 1995. The excess inventories, especially those stored in LME warehouses, that overhung the market in 1994 have diminished rapidly. As of the date of this report, LME inventories had dropped below the 1 million ton level, a decrease of more than 1.5 million tons in about 1 year. While some of the temporarily closed primary aluminum metal production capacity had come back on-line, most of the major world producers had yet to announce any restarts. Growth in worldwide aluminum demand was anticipated to continue but at a much slower pace than in 1994.

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[1] Excerpts from text of Memorandum of Understanding Concerning the Aluminum Market, January 28, 1994, and excerpts from various Chairman's Press Statements at follow-up MOU meetings.

[2] American Metal Market. Marc Rich Owns All Ravenswood. V. 102, No. 70, Apr. 13, 1994, p. 1.

[3] ———. Marc Rich Name Missing From the Firm He Founded. V. 102, No. 148, Aug. 8, 1994, p. 2.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Aluminum. Ch. in Mineral Commodity Summaries, annual.
Bauxite. Ch. in Mineral Commodity Summaries, annual.
Aluminum. Mineral Industry Surveys, monthly.
Bauxite and Alumina. Mineral Industry Surveys, quarterly.
Bauxite Mines Worldwide.
Primary Alumina Plants Worldwide, biennial.
Primary Aluminum Plants Worldwide, biennial.

Other Sources

Aluminum Association Inc. Aluminum Statistical Review, annual.
American Metal Market (daily paper).
CRU. Aluminum Metal Monitor (monthly).
Metal Bulletin.
Metals Week.

TABLE 1
SALIENT ALUMINUM STATISTICS 1/

(Thousand metric tons and million dollars unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Primary production	4,048	4,121	4,042	3,695	3,299
Value	$6,600	$5,400	$5,130	$4,340	$5,180
Price: (average cents per pound)					
U.S. market (spot)	74.0	59.5	57.5	53.3	71.2
Inventories (December 31)					
Aluminum industry	1,820	1,780	1,880	1,980 r/	2,070
LME stocks in U.S. warehouses	--	168	214	168	16
National Defense Stockpile	2	2	57	57	57
Secondary recovery 2/	2,390	2,290	2,760	2,940	3,080
New scrap	1,030	969	1,140	1,310	1,580
Old scrap	1,360	1,320	1,610	1,630	1,500
Exports (crude and semicrude)	1,660	1,760	1,450	1,210	1,370
Imports for consumption (crude and semicrude)	1,510	1,490	1,730	2,540	3,380
Aluminum industry shipments 3/	6,590	6,400	6,810	7,300	8,160
Supply, apparent 4/	6,300	6,010	6,870	7,920 r/	8,460
Consumption, apparent 5/	5,260	5,040	5,730	6,600 r/	6,880
World: Production	19,300	19,600	19,500	19,700 r/	19,100 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except "Prices" and "Primary production"; may not add to totals shown.

2/ Metallic recovery from purchased, tolled, or imported new and old scrap expanded for full industry coverage.

3/ Shipped to domestic industry.

4/ Defined as domestic primary metal production + secondary recovery + imports - exports + adjustments for Government and industry stock changes.

5/ Apparent supply less recovery from purchased new scrap.

TABLE 2
PRIMARY ANNUAL ALUMINUM PRODUCTION CAPACITY IN THE UNITED STATES, BY COMPANY 1/

Company	Yearend capacity (thousand metric tons)		1994 ownership (percent)
	1993	1994	
Alcan Aluminum Corp.:			
Sebree, KY	180	180	Alcan Aluminium Ltd., 100%.
Alumax Inc.:			
Ferndale, WA (Intalco)	275	275	Alumax Inc., 75%; Mitsui & Co., 11%; Toyo Sash, 7%; Yoshida Kogya K.K., 7%.
Frederick, MD (Eastalco)	170	170	Do.
Mount Holly, SC	184	184	Alumax, 73%; Clarendon Ltd., 27%.
Total	629	629	
Aluminum Co. of America: 2/			
Alcoa, TN	210	210	Aluminum Co. of America, 100%.
Badin, NC	115	115	Do.
Evansville, IN (Warrick)	300	300	Do.
Massena, NY	125	125	Do.
Rockdale, TX	315	315	Do.
Wenatchee, WA	220	220	Do.
Total	1,290	1,290	
Columbia Aluminum Corp.:			
Goldendale, WA	168	168	Columbia Aluminum Corp., 70%; employees, 30%.
Columbia Falls Aluminum Co.:			
Columbia Falls, MT	168	168	Montana Aluminum Investors Corp., 100%.
Kaiser Aluminum & Chemical Corp.:			
Mead, WA (Spokane)	200	200	MAXXAM Inc., 100%.
Tacoma, WA	73	73	Do.
Total	273	273	
NSA:			
Hawesville, KY	186	186	Southwire Co., 100%.
Noranda Aluminum Inc.:			
New Madrid, MO	215	215	Noranda Mines Ltd., 100%.
Northwest Aluminum Corp.:			
The Dalles, OR	82	82	Private interests, 100%.
Ormet Corp.:			
Hannibal, OH	245	245	Ohio River Associates Inc., 100%.
Ravenswood Aluminum Corp.:			
Ravenswood, WV	168	168	Glencore International AG, 100%
Reynolds Metals Co.:			
Longview, WA	204	204	Reynolds Metals Co., 100%.
Massena, NY	123	123	Do.
Troutdale, OR	121	121	Do.
Total	448	448	
Vanalco Inc.:			
Vancouver, WA	116	116	Vanalco Inc., 100%.
Grand total	4,160	4,160	

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Individual plant capacities are U.S. Bureau of Mines estimates based on company reported total.

TABLE 3
U.S. CONSUMPTION OF AND RECOVERY FROM PURCHASED NEW AND OLD ALUMINUM SCRAP 1/, BY CLASS 2/

(Metric tons)

Class	Consumption	Calculated recovery: Aluminum	Calculated recovery: Metallic
1993			
Secondary smelters	1,130,000	882,000	946,000
Intergrated aluminum companies	1,340,000	1,120,000	1,190,000
Independent mill fabricators	608,000	524,000	559,000
Foundries	89,900	74,300	79,900
Other consumers	9,560	9,560	9,560
Total	3,190,000	2,610,000	2,790,000
Estimated full industry coverage	3,360,000	2,750,000	2,940,000
1994			
Secondary smelters	1,150,000	887,000	951,000
Intergrated aluminum companies	1,340,000	1,120,000	1,190,000
Independent mill fabricators	728,000	628,000	670,000
Foundries	103,000	83,700	90,100
Other consumers	10,900	10,900	10,900
Total	3,340,000	2,730,000	2,910,000
Estimated full industry coverage	3,530,000	2,880,000	3,080,000

1/ Excludes recovery from other than aluminum-base scrap.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 4
U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF PURCHASED NEW AND OLD ALUMINUM SCRAP 1/ AND SWEATED PIG IN 1994 2/

(Metric tons)

Class of consumer and type of scrap	Stocks, Jan. 1	Net receipts 3/	Consumption	Stocks, Dec. 31
Secondary smelters:				
New scrap:				
Solids	4,252	167,291	166,820	4,723
Borings and turnings	3,966	187,632	187,111	4,487
Dross and skimmings	5,204	150,268	152,470	3,002
Other 4/	6,118	197,170	198,441	4,847
Total	19,540	702,361	704,842	17,059
Old scrap:				
Castings, sheet, clippings	14,955	294,220	292,407	16,768
Aluminum-copper radiators	1,099	9,055	9,338	816
Aluminum cans 5/	1,468 r/	100,636	100,426	1,678
Other 6/	254	41,391	41,192	453
Total	17,776 r/	445,302	443,363	19,715
Sweated pig	298	2,787	2,581	504
Total secondary smelters	37,614 r/	1,150,450	1,150,786	37,278
Integrated aluminum companies, foundries, independent mill fabricators, other consumers:				
New scrap:				
Solids	12,790 r/	701,340	694,535	19,595
Borings and turnings	291	37,289	37,215	365
Dross and skimmings	14	13,565	13,490	89
Other 4/	11,286	232,247	234,215	9,318
Total	24,381 r/	984,441	979,455	29,367
Old scrap:				
Castings, sheet, clippings	7,489	379,705	378,110	9,084
Aluminum-copper radiators	163	2,612	2,404	371
Aluminum cans	10,669	815,392	803,420	22,641
Other 6/	737 r/	11,143	11,725	155
Total	19,058 r/	1,208,852	1,195,659	32,251
Sweated pig	335	10,265	10,207	393
Total intergrated aluminum companies, etc.	43,774 r/	2,203,558	2,185,321	62,011
All scrap consumed:				
New scrap:				
Solids	17,042 r/	868,631	861,355	24,318
Borings and turnings	4,257	224,921	224,326	4,852
Dross and skimmings	5,218	163,833	165,960	3,091
Other 4/	17,404	429,417	432,656	14,165
Total new scrap	43,921 r/	1,686,802	1,684,297	46,426
Old scrap:				
Castings, sheet, clippings	22,444	673,925	670,517	25,852
Aluminum-copper radiators	1,262	11,667	11,742	1,187
Aluminum cans	12,137 r/	916,028	903,846	24,319
Other 6/	991 r/	52,534	52,917	608
Total old scrap	36,834 r/	1,654,154	1,639,022	51,966
Sweated pig	633	13,052	12,788	897
Total of all scrap consumed	81,388 r/	3,354,008	3,336,107	99,289

r/ Revised.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes imported scrap. According to reporting companies, 9.69% of total receipts of aluminum-base scrap, or 323,000 metric tons, was received on toll arrangements.

3/ Includes inventory adjustment.

4/ Includes data on foil, can stock clippings, and other miscellaneous.

5/ Used beverage cans toll treated for primary producers are included in secondary smelter tabulation.

6/ Includes municipal wastes (includes litter) and fragmentized scrap (auto shredder).

TABLE 5
PRODUCTION AND SHIPMENTS OF SECONDARY ALUMINUM ALLOYS BY INDEPENDENT SMELTERS IN THE UNITED STATES 1/

(Metric tons)

	1993		1994	
	Production	Net shipments 2/	Production	Net shipments 2/
Diecast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	45,500	44,700	50,500	51,200
380 and variations	518,000	517,000	559,000	560,000
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	85,100	84,400	86,400	85,900
No. 12 and variations	W	W	W	W
No. 319 and variations	67,400	65,700	70,500	71,200
F-132 alloy and variations	24,000	25,800	29,000	29,000
Al-Mg alloys	639	641	639	639
Al-Zn alloys	3,220	3,470	3,530	3,530
Al-Si alloys (0.6% to 2.0% Cu)	10,800	11,000	10,800	10,700
Al-Cu alloys (1.5% Si, maximum)	1,740	1,730	1,680	1,710
Al-Si-Cu-Ni alloys	1,360	1,400	1,180	1,230
Other	3,790	3,810	2,830	2,860
Wrought alloys: Extrusion billets	80,900	84,900	151,000	152,000
Miscellaneous:				
Steel deoxidation	--	--	--	--
Pure (97.0% Al)	--	--	--	--
Aluminum-base hardeners	93	93	93	93
Other 3/	34,200	35,200	35,700	35,000
Total	877,000	880,000	1,000,000	1,000,000
Less consumption of materials other than scrap:				
Primary aluminum	79,600	--	86,000	--
Primary silicon	39,200	--	67,500	--
Other	4,600	--	5,880	--
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot 4/	753,000	XX	843,000	XX

W Withheld to avoid disclosing company proprietary data; included with "Sand and permanent mold: Other." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes inventory adjustment.

3/ Includes other die-cast alloys and other miscellaneous.

4/ No allowance made for melt-loss of primary aluminum and alloying ingredients.

TABLE 6

DISTRIBUTION OF END-USE SHIPMENTS OF ALUMINUM PRODUCTS IN THE UNITED STATES, BY INDUSTRY 1/

Industry	1993 Quantity (thousand metric tons)	1993 Percent of grand total	1994 Quantity (thousand metric tons)	1994 Percent of grand total
Containers and packaging	2,180	26.0	2,280	24.4
Building and construction	1,240	14.7	1,400	15.0
Transportation	1,970 r/	23.5	2,310	24.7
Electrical	609	7.3	677	7.2
Consumer durables	563	6.7	647	6.9
Machinery and equipment	477	5.7	572	6.1
Other markets	259	3.1	276	2.9
Total to domestic users	7,300 r/	87.0 r/	8,160	87.2
Exports	1,090 e/	13.0 r/	1,200 e/	12.8
Grand total	8,390 r/	100.0	9,360	100.0

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: The Aluminum Association Inc.

TABLE 7

U.S. NET SHIPMENTS 1/ OF ALUMINUM WROUGHT AND CAST PRODUCTS, BY PRODUCERS 2/

(Thousand metric tons)

	1993	1994 p/
Wrought products:		
Sheet, plate, foil	4,030	4,740
Rod, bar, pipe, tube, and shapes	1,300 r/	1,440
Rod, wire, cable	297	356
Forgings (including impacts)	82 r/	92
Powder, flake, paste	59	63
Total	5,770 r/	6,700
Castings:		
Sand	103	NA
Permanent and semipermanent mold	225	NA
Die	645	NA
Other	20	NA
Total	994	NA
Grand total	6,770	NA

r/ Revised. p/ Preliminary. NA Not available.

1/ Net shipments derived by subtracting the sum of producers' domestic receipts of each mill shape from the domestic industry's gross shipments of that shape.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: U.S. Department of Commerce.

TABLE 8
U.S. EXPORTS OF ALUMINUM, BY COUNTRY 1/

Country	Metals and alloys, crude		Plates, sheets, bars, etc. 2/		Scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
Brazil	61	$158	8,410	$24,500	707	$779	9,170	$25,400
Canada	80,700	114,000	320,000	690,000	46,500	47,300	448,000	852,000
France	922	1,570	5,350	12,100	582	785	6,860	14,500
Germany	209	485	10,800	20,700	85	217	11,100	21,400
Hong Kong	5,090	6,300	3,490	13,000	7,970	5,620	16,500	25,000
Japan	220,000	280,000	15,900	71,700	92,300	94,800	328,000	447,000
Korea, Republic of	20,700	26,700	11,200	34,600	8,160	9,810	40,100	71,200
Mexico	33,800	56,500	67,000	202,000	18,300	20,000	119,000	278,000
Netherlands	203	445	3,590	8,850	272	305	4,060	9,600
Philippines	3,050	3,940	186	795	135	129	3,370	4,860
Russia	--	--	184	1,760	--	--	184	1,760
Saudi Arabia	19	40	20,100	43,900	--	--	20,100	44,000
Singapore	69	244	3,840	12,200	718	900	4,630	13,400
Taiwan	22,900	26,700	15,800	40,300	16,300	11,600	55,000	78,600
Thailand	7,030	8,820	5,300	11,400	1,030	1,130	13,400	21,300
United Kingdom	512	2,310	17,600	47,000	229	424	18,300	49,700
Venezuela	85	349	16,400	38,700	8	55	16,500	39,100
Other r/	4,820	11,400	69,000	203,000	18,300	17,500	92,100	232,000
Total	400,000	541,000	594,000	1,480,000	212,000	211,000	1,210,000	2,230,000
1994:								
Brazil	194	464	11,800	31,400	631	868	12,700	32,800
Canada	114,000	182,000	366,000	850,000	57,900	61,200	537,000	1,090,000
France	21	214	5,110	25,300	33	211	5,160	25,700
Germany	237	699	8,550	23,700	189	144	8,980	24,600
Hong Kong	2,670	4,090	5,420	18,100	19,200	22,000	27,300	44,200
Japan	141,000	204,000	16,800	74,700	105,000	130,000	263,000	409,000
Korea, Republic of	19,000	29,700	16,000	55,800	16,100	20,700	51,100	106,000
Mexico	33,700	66,400	84,100	256,000	24,000	30,500	142,000	353,000
Netherlands	19	181	992	4,840	212	389	1,220	5,410
Philippines	1,170	1,530	154	1,710	37	21	1,360	3,270
Russia	--	--	86	929	65	107	151	1,040
Saudi Arabia	8	41	33,200	58,900	--	--	33,200	58,900
Singapore	138	357	4,080	11,600	242	232	4,460	12,100
Taiwan	15,500	24,900	24,100	59,700	56,100	50,700	95,600	135,000
Thailand	7,880	12,900	3,700	8,850	1,530	2,610	13,100	24,300
United Kingdom	163	1,170	21,200	62,000	52	45	21,400	63,200
Venezuela	37	244	16,400	40,200	111	49	16,600	40,500
Other	3,120	6,700	102,000	259,000	25,700	27,700	130,000	294,000
Total	339,000	536,000	719,000	1,840,000	307,000	348,000	1,370,000	2,730,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes castings, forgings, and unclassified semifabricated forms.

Source: Bureau of the Census.

TABLE 9
U.S. EXPORTS OF ALUMINUM, BY CLASS 1/

Class	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	400,000	$541,000	339,000	$536,000
Scrap	212,000	211,000	307,000	348,000
Plates, sheets, bars, strip, etc.	571,000	1,350,000	683,000	1,680,000
Castings and forgings	6,060	55,800	5,610	62,400
Semifabricated forms, n.e.c.	17,600	75,200	30,000	105,000
Total	1,210,000	2,230,000	1,370,000	2,730,000
Manufactures:				
Foil and leaf	53,200	153,000	77,800	193,000
Powders and flakes	5,080	18,400	5,610	22,000
Wire and cable	40,200	98,700	54,600	136,000
Total	98,500	270,000	138,000	352,000
Grand total	1,310,000	2,500,000	1,500,000	3,080,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM, BY CLASS 1/

Class	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	1,840,000	$2,150,000	2,480,000	$3,480,000
Plates, sheets, strip, etc., n.e.c. 2/	344,000	712,000	375,000	804,000
Pipes, tubes, etc.	5,340	29,000	7,550	36,500
Rods and bars	50,900	96,300	125,000	241,000
Scrap	309,000	276,000	390,000	436,000
Total	2,540,000	3,260,000	3,380,000	5,000,000
Manufactures:				
Foil and leaf 3/	35,900	128,000	47,300	158,000
Flakes and powders	1,660	4,310	1,630	3,910
Wire	18,500	30,600	51,300	83,300
Total	56,000	163,000	100,000	245,000
Grand total	2,600,000	3,420,000	3,480,000	5,240,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Includes plates, sheets, circles, and disks.
3/ Excludes etched capacitor foil.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM, BY COUNTRY 1/

Country	Metals and alloys, crude		Plates, sheets, bars, etc. 2/		Scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
Australia	1	$2	1,150	$2,070	300	$196	1,450	$2,270
Bahrain	--	--	7,890	14,700	--	--	7,890	14,700
Belgium	275	399	7,170	15,500	372	515	7,820	16,400
Brazil	52,300	65,600	4,370	8,980	4	14	56,700	74,600
Canada	1,220,000	1,490,000	244,000	452,000	179,000	166,000	1,650,000	2,110,000
France	2,430	4,910	10,500	31,600	2,010	1,470	14,900	37,900
Germany	2,370	6,000	18,600	68,900	9,190	9,770	30,200	84,700
Japan	542	954	15,400	53,700	250	499	16,200	55,100
Mexico	63	134	2,630	7,440	46,500	38,000	49,200	45,600
Netherlands	4,230	4,300	4,310	12,700	4,930	6,120	13,500	23,100
Norway	184	1,340	1,900	2,950	--	--	2,090	4,290
Russia	421,000	446,000	9,620	13,600	18,600	18,200	450,000	478,000
South Africa, Republic of	247	667	3,350	6,060	21	4	3,620	6,730
Spain	3,120	2,990	18,000	28,100	390	408	21,600	31,500
Tajikistan	18,100	17,400	--	--	--	--	18,100	17,400
Ukraine	--	--	--	--	110	698	110	698
United Arab Emirates	2,990	3,960	--	--	--	--	2,990	3,960
United Kingdom	4,420	6,120	6,460	23,200	4,730	4,620	15,600	33,900
Venezuela	63,700	70,200	15,700	25,100	25,700	16,900	105,000	112,000
Other r/	37,300	27,900	28,800	71,000	16,600	12,700	82,700	112,000
Total	1,840,000	2,150,000	400,000	838,000	309,000	276,000	2,540,000	3,260,000
1994:								
Australia	576	862	580	1,280	999	883	2,160	3,030
Bahrain	--	--	9,430	17,800	--	--	9,430	17,800
Belgium	20	63	8,080	18,800	254	244	8,350	19,100
Brazil	143,000	192,000	4,890	8,800	8	23	148,000	201,000
Canada	1,430,000	2,080,000	307,000	606,000	214,000	248,000	1,950,000	2,930,000
France	6,560	12,700	10,900	33,700	1,510	1,770	18,900	48,200
Germany	3,480	8,230	21,400	76,000	12,500	15,200	37,400	99,400
Japan	386	837	11,000	37,700	779	1,040	12,100	39,600
Latvia	7,630	9,090	--	--	--	--	7,630	9,090
Mexico	404	647	4,190	9,930	68,500	76,100	73,100	86,700
Netherlands	13,300	19,700	4,630	14,000	4,800	5,720	22,700	39,500
Norway	164	1,200	769	1,500	--	--	933	2,700
Russia	643,000	858,000	33,600	51,400	13,700	19,100	690,000	928,000
South Africa, Republic of	396	840	3,430	6,370	495	170	4,320	7,380
Spain	6,130	7,370	25,200	42,000	616	658	32,000	50,000
Tajikistan	53,400	45,700	--	--	--	--	53,400	45,700
Ukraine	3,730	4,840	(3/)	4	190	147	3,920	5,000
United Arab Emirates	1,890	2,440	--	--	184	246	2,070	2,690
United Kingdom	4,630	6,530	9,510	32,300	13,500	14,700	27,700	53,600
Venezuela	126,000	161,000	27,700	46,800	35,800	32,600	190,000	241,000
Other	43,300	66,800	24,900	77,400	21,700	19,200	89,900	163,000
Total	2,480,000	3,480,000	507,000	1,080,000	390,000	436,000	3,380,000	5,000,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes circles, disks, rods, pipes, tubes, etc.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 12
ALUMINUM, PRIMARY: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Argentina e/	166 3/	165	165	165	165
Australia	1,230	1,230	1,240	1,380 r/	1,320 3/
Austria	89	80	33	--	--
Azerbaijan e/	XX	XX	25	20	15
Bahrain	213	227	292	447 r/	450
Bosnia and Herzegovina e/ 4/	XX	XX	30	15	10
Brazil	931	1,140	1,190 r/	1,170 r/	1,200
Cameroon	93	83	82 e/	82 e/	82
Canada	1,570	1,820	1,970	2,310	2,250 3/
China e/	850	963	1,100	1,220	1,450
Croatia e/ 4/	XX	XX	20	20	20
Czechoslovakia e/ 5/ 6/ 7/	70	68	68	XX	XX
Egypt	179	178	178	180 r/	180
France	326	286	418	426 r/	400
Germany:					
Eastern states	20	XX	XX	XX	XX
Western states	720	XX	XX	XX	XX
Total	740	690	603	552	503 3/
Ghana	174	175	180	175	141 3/
Greece	150	152	153	148 r/	138 3/
Hungary	75	63	27	28	29
Iceland 8/	87	89	89	94 r/	99 3/
India 7/	433	504	496 r/	466 r/	441 3/
Indonesia 7/	186	187	173	206 r/	220
Iran e/	60	80	92	90 r/	116
Italy	232	206	161	156 r/	160
Japan 9/	34	32	19	18	17 3/
Korea, Republic of 7/	2	--	--	--	--
Mexico 7/	68	51	25	-- r/	--
Netherlands	270	264	235	232 r/	219 3/
New Zealand	260	258	243	277 r/	271 3/
Norway	845	833	813	887 r/	857 3/
Poland 10/	46	46	44	47	47
Romania 11/	168	113	112	112 e/	112
Russia	XX	XX	2,700	2,820 r/	2,670 3/
Serbia and Montenegro 4/	XX	XX	67 r/	26 r/	7 3/
Slovakia 6/ 7/	XX	XX	XX	60 e/	60
Slovenia 4/	XX	XX	85	80 e/	80
South Africa, Republic of	159	169	173	175	173
Spain	353	355	359	356 r/	340
Suriname	32	29	32	32 r/	34
Sweden	96	97	77	82 r/	83
Switzerland	72	66	52	36 r/	31 3/
Tajikistan e/	XX	XX	400	250 r/	250
Turkey	61	56	59	59	60
U.S.S.R. 12/	3,520	3,250	XX	XX	XX
Ukraine e/	XX	XX	90	90	85
United Arab Emirates: Dubai	174	239	245 r/	242 r/	250
United Kingdom	294	294	244	239 r/	230
United States	4,050	4,120	4,040	3,700	3,300 3/
Venezuela	590	601	561	570 e/	580
Yugoslavia 7/ 13/	349	315	XX	XX	XX
Total	19,300	19,600	19,500	19,700 r/	19,100

See footnotes at end of table.

e/ Estimated. r/ Revised. XX Not applicable.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ The U.S. Bureau of Mines defines primary aluminum as "The weight of liquid aluminum as tapped from pots, excluding the weight of any alloying materials as well as that of any metal produced from either returned scrap or remelted materials." International reporting practices vary from country to country, some nations conforming to the foregoing definition and others using different definitions. For those countries for which a different definition is given specifically in the source publication, that definition is provided in this table by footnote. Table includes data available through May 22, 1995.
3/ Reported figure.
4/ Primary ingot plus secondary ingot.
5/ Dissolved Dec. 31,1992.
6/ All production in Czechoslovakia from 1990-92 came from Slovakia.
7/ Primary ingot.
8/ Ingot and rolling billet production.
9/ Excludes high-purity aluminum containing 99.995% or more as follows, in metric tons: 1990--16,300; 1991--19,700; 1992--19,600; 1993--20,300; 1994--23,800.
10/ Primary unalloyed ingot plus secondary unalloyed ingot.
11/ Primary unalloyed metal plus primary alloyed metal, thus including weight of alloying material.
12/Dissolved in Dec. 1991.
13/Dissolved in Apr. 1992.

ANTIMONY

By James F. Carlin, Jr.

Domestic consumption of primary antimony increased substantially in 1994, as did primary and secondary production. Imports of and exports antimony products increased markedly.

Primary antimony metal and oxide were produced by six companies operating six plants using both foreign and domestic feed material. Two plants were in Texas, and there was one each in Idaho, Montana, Nebraska, and New Jersey. Most domestic antimony smelter activity involved upgrading imported antimony oxide to higher purity. A small amount of antimony was recovered as a byproduct from the smelting of lead and silver-copper ores, but most primary antimony metal and oxide produced domestically originated from imports. The estimated value of primary antimony metal and oxide produced in 1994 was $120 million. The estimated distribution of primary antimony uses was as follows: flame retardants, 57%; transportation, including batteries, 22%; chemicals, 8%; ceramics and glass, 7%; and other, 6%. (See tables 3, 4, and 5.)

Secondary antimony produced from domestic scrap source materials was derived mainly from recycled lead-acid batteries. Recycling plus domestic mine output supplied less than one-half of the estimated domestic demand for antimony.

Antimony was mined as a principal product and produced as a byproduct of the smelting of base metal ores in 18 countries. Bolivia, China, Russia, the Republic of South Africa, and Russia together accounted for more than 90% of mine production; China alone accounted for more than 70% of the total world estimated mine antimony production. Identified world antimony reserves at yearend 1994 were estimated to be 4.2 million metric tons. (See table 10.)

Legislation and Government Programs

Public Laws 102-484 and 103-160 provided authorization for additional antimony monthly sales through 1994, or until the 2,722 tons (3,000 short tons) authorized for sale is disposed. Sales of antimony from the National Defense Stockpile took place for the second consecutive year since earlier sales in 1988. Sales were conducted on a sealed bid basis and were held in January, June, October, November, and December. Sales were held the third Thursday of each month. Each month a maximum of 454 tons (500 short tons) of antimony, either Grade A or Grade B, was offered, usually in the form of ingots or cakes. In 1994, a total of 1,852 tons (2,041 short tons) was sold, with 1,144 tons (1,261 short tons) of the total coming in June. Antimony is stockpiled in Government warehouses in 12 locations, with the Somerville, NJ, depot holding the largest amount.

Production

Mine Production.—In the Coeur d' Alene District of Idaho, Sunshine Mining Co. produced antimony as a byproduct of the treatment of tetrahedrite, a complex silver-copper-antimony sulfide ore. A voluntary U.S. Bureau of Mines canvass form was sent to the lone mine producer and a reply was received.

Smelter Production.—The producers of primary antimony metal and oxide products were ASARCO Incorporated, Omaha, NE; Amspec Chemical Corp., Gloucester City, NJ; Anzon Inc., Laredo, TX; Laurel Industries Inc., La Porte, TX; Sunshine Mining Co., Kellogg, ID; and U.S. Antimony Corp, Thompson Falls, MT. A voluntary U.S. Bureau of Mines canvass form was sent to each of these six primary smelters, and a reply was received from each.

Old scrap, predominantly lead battery plates, was the source of almost all of the secondary antimony output. New scrap, mostly in the form of drosses and residues from various sources, supplied the remainder. Antimonial lead was the main market for scrap antimony.

Consumption

Domestic consumption of primary antimony increased moderately in 1994. The most significant increases occurred in the categories of antimonial lead and plastics. Lead-antimony alloys were used in starting-lighting-ignition batteries, ammunition, corrosion-resistant pumps and pipes, tank linings, roofing sheets, solder, cable sheaths, and antifriction bearings. Antimony compounds were used in plastics as stabilizers and as flame retardants. Antimony trioxide in an organic solvent was used to make textiles, plastics, and other combustibles flame resistant. Antimony was used as a decolorizing and refining agent in some forms of glass, such as optical glass.

Of the 203 consumers to which a voluntary U.S. Bureau of Mines canvass form was sent, all responded.

Prices

In 1994, antimony metal prices surged strongly. This was attributed initially to shipment delays from the world's largest producer, China, in the early Spring, followed by extensive flooding in the regions of China's major antimony mines and smelters in the late Spring. Production and shipping delays in China reportedly persisted most of the year.

The New York dealer antimony metal price, published by Platt's Metals Week, averaged $1.78 per pound for the year compared with $0.77 per pound in 1993. The price range for high-tint antimony trioxide, published by American Metal Market, was $1.00 to $1.30 per pound at the beginning of the year and rose to a range of $3.50 to $3.75 by the fourth quarter.

Foreign Trade

Imports of antimony metal rose during the year. China supplied about 83% of the antimony metal. Imports of antimony oxide increased moderately during the year, with China supplying about 38%. (See tables 8 and 9.)

Outlook

Antimony demand rose moderately in 1994, continuing the pattern of steady or rising demand in recent years. That demand increase occurred at a time of surging prices, indicating perhaps the strength of the underlying demand. Much of that consumption increase was in the category of flame retardants, and it is believed that field should expand, although tin and other metals are attempting to penetrate that field with acceptable substitutes having commendable qualities of their own.

It is anticipated that the reliance of the United States on imported antimony materials will continue, with China's dominance as a supplier of antimony being a continuing factor.

OTHER SOURCES OF INFORMATION

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Antimony. Ch. in Mineral Facts and Problems, 1985 ed.

Other Sources

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TABLE 1
SALIENT ANTIMONY STATISTICS 1/

(Metric tons of antimony content unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production:					
Primary:					
Mine (recoverable antimony)	W	W	W	W	W
Smelter	20,600 r/	16,400 r/	20,100 r/	22,600 r/	25,500
Secondary	20,400	19,300	19,900	20,700 r/	24,300
Exports of metal, alloys, waste and scrap	588	694	947	315	1,350
Exports of antimony oxide	7,140	3,750	4,820 e/	3,900 e/	6,500 e/
Imports for consumption	29,400	28,800	31,200	30,900	41,500
Reported industrial consumption, primary antimony	12,800	11,900	12,200	12,400 r/	14,800
Stocks: Primary antimony, all classes, Dec. 31	8,180	10,200	8,740	9,080 r/	10,900
Price: Average, cents per pound 2/	81.8	82.0	79.0	76.9	177.7
World: Mine production	94,400	92,500 r/	76,100 r/	86,300 r/	108,000 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ New York dealer price for 99.5% to 99.6% metal, c.i.f. U.S. ports.

TABLE 2
SECONDARY ANTIMONY PRODUCED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY 1/

(Metric tons of antimony content unless otherwise specified)

	1993	1994
KIND OF SCRAP		
New scrap: Lead- and tin-base	1,540 r/	1,740
Old scrap: Lead- and tin-base	19,200 r/	22,600
Total	20,700 r/	24,300
FORM OF RECOVERY		
In antimonial lead	20,300 r/	24,000
In other lead- and tin-base alloys	435 r/	332
Total	20,700 r/	24,300
Value millions	$43	$51

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices; may not add to totals shown.

TABLE 3
REPORTED INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED-STATES 1/

(Metric tons of antimony content)

Year	Class of material consumed			Total
	Metal	Oxide	Other 2/	
1993	2,150 r/	10,100 r/	114	12,400 r/
1994	2,550	12,100	124	14,800

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes sulfide and residues.

TABLE 4
REPORTED INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES, BY PRODUCT 1/

(Metric tons of antimony content)

Product	1993	1994
Metal products:		
Antimonial lead	1,110 r/	1,990
Bearing metal and bearings	44 r/	36
Castings	14	6
Solder	242	179
Other 2/	1,390 r/	1,520
Total	2,810 r/	3,730
Nonmetal products:		
Ammunition primers	24	32
Ceramics and glass	848 r/	980
Pigments	489 r/	369
Plastics	786 r/	1,030
Other 3/	161 r/	77
Total	2,310 r/	2,490
Flame-retardants:		
Adhesives	281 r/	357
Plastics	5,440 r/	6,710
Rubber	344 r/	433
Textiles	431 r/	466
Other 4/	758	622
Total	7,250 r/	8,590
Grand total	12,400 r/	14,800

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes ammunition, cable covering, collapsible tubes and foil, sheet and pipe, and type metal.

3/ Includes fireworks and rubber products.

4/ Includes paper and pigments.

TABLE 5
INDUSTRY STOCKS OF PRIMARY ANTIMONY IN THE UNITED STATES, DECEMBER 31 1/

(Metric tons of antimony content)

Stocks	1993	1990
Metal	2,790 r/	2,770
Oxide	3,320 r/	4,990
Other 2/	2,970	3,170
Total	9,080 r/	10,900

r/ Revised.

1/ Previously published and 1994 data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes ore and concentrate, sulfide and residues.

TABLE 6
U.S. EXPORTS OF ANTIMONY METAL, ALLOYS, AND WASTE AND SCRAP, BY COUNTRY 1/

Country	1993		1994	
	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Mexico	46	$95	360	$1,450
Taiwan	--	--	470	3,410
Other	269 r/	776 r/	521	2,610
Total	315	871	1,350	7,470

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
U.S. EXPORTS OF ANTIMONY OXIDE, BY COUNTRY 1/

Country	1993			1994		
	Gross weight (metric tons)	Antimony content 2/ (metric tons)	Value (thousands)	Gross weight (metric tons)	Antimony content 2/ (metric tons)	Value (thousands)
Australia	43	36	$114	254	211	$349
Brazil	27	22	102	359	298	760
Canada	816	677	2,070	2,040	1,690	4,250
Colombia	34	28	147	288	239	393
Germany	122	101	372	129	107	129
Italy	362	300	362	245	203	327
Japan	540	448	1,230	721	598	1,760
Mexico	1,410	1,170	1,620	1,390	1,150	1,620
Netherlands	26	22	26	477	396	659
Singapore	748	621	1,390	927	769	2,140
Taiwan	17	14	62	150	125	850
Turkey	46	38	154	333	276	484
United Kingdom	127	105	328	205	170	609
Other	380 r/	315 r/	909 r/	322	266	709
Total	4,690	3,900	8,890	7,840	6,500	15,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Estimated by the U.S. Bureau of Mines.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF ANTIMONY, BY CLASS AND COUNTRY 1/

Country	1993 Gross weight (metric tons)	1993 Antimony content 2/ (metric tons)	1993 Value (thousands)	1994 Gross weight (metric tons)	1994 Antimony content 2/ (metric tons)	1994 Value (thousands)
Antimony ore and concentrate:						
Bolivia	--	--	--	3,660	3,000	$8,970
Canada	1,500	374	$775	1,310	381	808
China	97	83	136	608	526	1,720
Kyrgyzstan	--	--	--	1,180	966	3,590
United Kingdom	--	--	--	807	661	1,610
Other	125	86	154	113	99	174
Total	1,720	543	1,070	7,680	5,640	16,900
Antimony oxide:						
Belgium	867	720	2,430	1,010	834	4,310
Bolivia	3,350	2,780	5,020	3,210	2,660	4,880
China	7,020	5,830	9,180	7,960	6,610	22,200
France	241	200	521	274	228	857
Germany	331	275	1,780	154	128	1,740
Hong Kong	201	167	349	170	141	357
Kyrgyzstan	661	549	835	1,050	870	2,370
Mexico	3,060	2,540	2,540	3,930	3,260	2,670
Russia	198	164	236	--	--	--
South Africa, Republic of	3,030	2,510	906	3,200	2,650	925
United Kingdom	67	55	284	247	205	883
Other	293 r/	245 r/	773 r/	111	93	629
Total	19,300	16,000	24,800	21,300	17,700	41,800

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Antimony ore and concentrate content reported by Bureau of the Census. Antimony oxide content estimated by the U.S. Bureau of Mines.

Source: Bureau of the Census.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF ANTIMONY METAL, BY COUNTRY 1/

Country	1993 Quantity (metric tons)	1993 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Bolivia	174	$230	375	$1,410
Chile	40	54	72	101
China	12,300	20,400	15,500 2/	50,500 2/
Hong Kong	396	652	268	701
Kyrgyzstan	560	831	291	1,350
Japan	72	1,900	72 2/	4,340 2/
Mexico	366	184	1,070	582
Thailand	160	467 r/	178	520
United Kingdom	83	224	192	1,060
Other	180 r/	686 r/	197	1,080
Total	14,400	25,600	18,200	61,700

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ All or part of these data have been referred to the Bureau of the Census for verification.

Source: Bureau of the Census.

TABLE 10
ANTIMONY: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Australia 3/	1,420	1,500 e/	1,700	1,700 e/	1,700
Austria 4/	352	--	--	--	--
Bolivia	8,450	7,290	6,020	4,160 r/	5,700
Canada 4/	658	469	948	673 r/	750 5/
China e/	54,800	58,300	45,000	60,000 r/	80,000
Czech Republic	XX	XX	XX	250 e/	-- 5/
Czechoslovakia e/ 6/	1,270	1,000	1,000	XX	XX
Guatemala	1,070	609	582	600	600
Kyrgyzstan e/	XX	XX	3,000 r/	2,500 r/	2,500
Mexico 7/	1,670	1,470	1,200 e/	1,470	1,500
Morocco 4/	192	168 r/	197 r/	180 r/	180
Namibia (content of sodium antimonate)	2	10	6	8	14 5/
Pakistan e/	9	11	12	--	--
Peru (recoverable)	307	278	311 r/	215 r/	300
Russia e/ (recoverable)	XX	XX	10,000	8,000 r/	7,000
Slovakia 6/	XX	XX	XX	450 e/	400
South Africa, Republic of 4/	4,820	4,490	3,780	4,110 r/	5,600
Tajikistan e/	XX	XX	1,500	1,200	1,000
Thailand (content of ore and concentrate)	326	60	269	620 r/	500
Turkey	552	370	309	116 r/	100
U.S.S.R. e/ 8/	18,000	16,000	XX	XX	XX
United States	W	W	W	W	W
Yugoslavia 9/	409	350 e/	XX	XX	XX
Zimbabwe 4/	101	160	254	95 r/	100
Total	94,400	92,500	76,100 r/	86,300 r/	108,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Antimony content of ore unless otherwise indicated. Table includes data available through June 12, 1995.

3/ Antimony content of antimony ore and concentrate, lead concentrates, and lead-zinc concentrates.

4/ Antimony content of concentrate.

5/ Reported figure.

6/ Dissolved Dec. 31, 1992.

7/ Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced.

8/ Dissolved in Dec. 1991.

9/ Dissolved in Apr. 1992.

ARSENIC

By Daniel L. Edelstein

The United States was the world's largest consumer of arsenic in 1994, accounting for about one-half of world demand. Domestic demand remained unchanged in 1994; a decline in use for agricultural products was balanced by increased demand for use in wood preservatives and nonferrous alloys. All domestic arsenic requirements were met by imports; arsenic production in the United States was last reported in 1985. On a contained metal basis, arsenic trioxide accounted for 94% of imports. China, the world's largest producer of both arsenic trioxide and arsenic metal, was the leading source of U.S. imports of both products.

Legislation and Government Programs

Local and state concern over the toxicity of chromated copper arsenate (CCA) wood preservatives led to State restrictions on their use in certain applications. Responding to concern that CCA could leach from timbers and accumulate in invertebrate marine life, New Jersey became the first State to restrict their use in certain marine applications. Effective July 19, 1994, restrictions on the use of CCA pressure-treated wood were imposed along four rivers that are rich in shellfish. Accordingly, CCA treated wood will be prohibited in the construction of new or rebuilt marine structures at marinas containing slips for five or more boats. However, in recognition of a lack of alternative materials, pilings were exempt from the ban.[1] Alternative materials for planking include plastic lumbers and South American hardwood.

Consumption

Consumption of arsenic remained unchanged in 1994, despite a decline in agricultural uses. In 1993, following a negotiated agreement, EPA canceled the registrations of companies producing arsenic acid desiccant for cotton crops. At that time, two companies were producing arsenic acid desiccant, Elf Atochem North America and Volunteer Purchasing Company, Inc.

Demand for arsenic in the wood preservative industry increased during 1994, and accounted for more than 80% of domestic demand. Arsenic trioxide was consumed in the production of arsenic acid for formulation of wood preservatives by the three principal producers of arsenical wood preservatives; Hickson Corp. in Conley, GA; CSI in Harrisburg, NC; and Osmose Corp., in Memphis, TN. Osmose, which formerly purchased some arsenic acid, expanded arsenic acid facilities in 1994 to become self-sufficient in acid production. Chromated copper arsenate is the most commonly used arsenic-based wood preservative. Other arsenic-based wood preservatives include ammoniacal copper arsenate (ACA) and fluor chrome arsenate phenol (FCAP).

The remaining agricultural use for arsenic was as an herbicide (MSMA and DSMA) for control of weeds. ISK Bioscience, Mentor, OH, produced the arsenical herbicide monosodium methanearsonate (MSMA) at a plant in Houston, TX. Minor amounts of arsenic acid were consumed in glass manufacturing, as a fining agent to disperse bubbles that tend to form when certain types of glass are produced. Commercial grade arsenic metal, 99% pure, was used in lead- and copper-based alloys as a minor additive (0.01% to 0.5%) to increase strength in the posts and grids of lead-acid storage batteries and to improve corrosion resistance and tensile strength in copper alloys. Apparent metallurgical demand increased significantly in 1994. Domestic production of automotive batteries increased by more than 13%, accounting for at least some of the increased demand. Potential supply disruptions may also have encouraged inventory building by domestic consumers. About 15 tons of high-purity arsenic metal, 99.9999% or higher purity, was used in the manufacture of crystalline gallium arsenide, a semiconducting material used in optoelectronic circuitry, high-speed computers, and other electronic devices.

Prices

Prices for arsenic trioxide are not published, although historical prices from 1955 to 1991 are listed in the Chemical Economics Handbook, published by SRI International, Menlo Park, CA. Prices for high—grade (minimum 99%) arsenic trioxide are generally quoted at an 8-12 cents per pound premium to low-grade (minimum 95%) arsenic trioxide. The average price for imported arsenic trioxide in 1994 was 26 cents per pound, while high-purity trioxide from Mexico averaged 32 cents per pound. As well as its higher purity, Mexican trioxide had the advantage of bulk shipping via rail cars; consumers thus avoided having to handle and dispose of contaminated drums. The average customs price for imported Chinese metal, which declined slightly during 1994, rose precipitously at yearend, averaging 92 cents per pound in December. This compared with an average of only 33 cents per pound during the first 10 months of the year. The customs price rise corresponded to industry reports that low prices and flooding had caused closures or cutbacks at several Chinese plants.

World Review

Arsenic was recovered as arsenic trioxide from the smelting or roasting of nonferrous metal ores or concentrates in at least 18 countries. China was the world's largest producer as well as the major source for U.S. imports. In 1991, Ghana first reported production of a small quantity of arsenic trioxide from roasting operations at the newly commissioned Bogosu gold mine. About 1,500 tons of arsenic trioxide production were reported in 1993. In 1992, the Ashanti gold mine became the second arsenic trioxide producer in Ghana. As part of a major mine rehabilitation and expansion project at Ashanti, sulfide ore flotation and roasting capacity were upgraded and an arsenic scrubber installed. By 1993, the scrubber was reported to be recovering 25 tons per day of crude trioxide (9,000 tons per year).

Production of trioxide in Ghana reportedly rose to about 9,000 tons in 1993. However, the Ashanti scrubber was reportedly closed during 1994. The majority of Ghanaian trioxide was not believed to be of commercial grade, and hence most production from Ghana has been omitted from the world table. Industry reports indicate that about 3,000 tons of Ashanti crude trioxide were processed to refined trioxide in France.

In France, Societe d'Exploitation Pyrometalurgie Salsigne, formed in November 1992, began commercial production of arsenic trioxide in 1993. The company, which purchased the gold smelter and roaster formerly operated by Mines et Produits Chimiques de Salsigne, has the capacity to produce significant quantities of refined arsenic trioxide. A second producer, Metaleurop SA, with capacity to produce about 6,000 tons per year of high-purity trioxide, reportedly processed some imported crude trioxide from Ghana.

Arsenic metal, which accounts for only 3% of world demand for arsenic, was produced by the reduction of arsenic trioxide. Commercial-grade arsenic metal, 99% pure, accounted for the majority of world arsenic metal production, and was produced only in China. High-purity arsenic, 99.9999% pure or greater, for use in the semiconductor industry was produced by about 10 companies. Furukawa Electric Co. Ltd. in Japan and Preussag AG in Germany were believed to be the world's largest producers, with capacities of 30 and 15 metric tons per year, respectively.

Outlook

With the major market for arsenic being the production of arsenical wood preservatives, the demand for arsenic is closely tied to the home construction market, where wooden decks containing arsenical preservatives have become ubiquitous. Demand for treated wood rose precipitously in the 5-year period ending in 1988, as the market for CCA treated wood matured. In 1989 about 450 million cubic feet of wood were treated with waterborne preservatives (98% estimated to be CCA), compared with 300,000 cubic feet in 1984. In 1993, the last year for which data are available, about 470 million cubic feet of wood were treated with waterborne preservatives, or about 75% of all treated lumber.[2]

The apparent demand for arsenic trioxide rose during 1994 on the strength of new home construction; housing starts rose by almost 13% in 1994. Future demand for arsenic is expected to closely follow that for new home construction. In the short term, higher interest rates could limit growth in demand. The prohibition on use of CCA preservatives in certain applications, and the greater acceptance of alternative preservatives, could negatively impact future demand.

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[1] New York Times. Curbs Due on Pressure Treated Wood. July 10, 1994, p. 2.

[2] Micklewright, James T. Wood Preservation Statistics, 1993, A report to the Wood-Preserving Industry in the United States. May 1994.

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The Material Flow of Arsenic in the United States, IC 9382.

Other Sources

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TABLE 1
ARSENIC SUPPLY-DEMAND RELATIONSHIPS, 1990-94 1/

(Metric tons, arsenic content)

	1990	1991	1992	1993	1994
U.S. supply:					
Imports, metal	796	1,010	740	767	1,330
Imports, compounds	19,900	20,700	23,300	20,900	20,300
Industry stocks, Jan. 1	100	100	--	--	--
Total	20,800	21,800	24,000	21,600	21,600
Distribution of U.S. supply:					
Industry stocks, Dec. 31	100	--	--	--	--
Exports 2/	149	233	94	364	79
Apparent demand	20,500	21,600	23,900	21,300	21,500
Estimated U.S. demand pattern:					
Agricultural chemicals	4,200	5,000	3,900	3,000	1,200
Glass	800	900	900	900	700
Wood preservatives	14,400	14,300	17,900	16,200	18,000
Nonferrous alloys and electronics	800	1,000	800	800	1,300
Other	300	400	400	400	300
Total	20,500	21,600	23,900	21,300	21,500

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Exports for 1990 include compounds; exports for 1991 through 1994 include metal only.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF ARSENICALS 1/

Class and country	1993 Quantity (metric tons)	1993 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Arsenic trioxide:				
Belgium	678	$456	950	$537
Chile	6,050	2,880	3,720	1,680
China	11,700	6,640	15,300	8,630
France	1,890	1,250	2,460	1,420
Germany	15	26	--	--
Hong Kong	1,650	919	336	172
Mexico	3,910	2,850	3,440	2,450
Philippines	1,150	540	351	172
South Africa, Republic of	120	69	--	--
United Kingdom	17	23	--	--
Other	353	221	257	148
Total	27,500	15,900	26,800	15,200
Arsenic acid:				
Canada	--	--	5	10
Arsenic metal:				
Canada	(2/)	11	--	--
China	691	663	1,150	1,020
Germany	11	932	9	1,140
Hong Kong	17	20	106	147
Japan	47	760	33	1,060
United Kingdom	1	15	1	10
Other	--	--	34	28
Total	767	2,400	1,330	3,410

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 3
AVERAGE ARSENIC PRICES

(Cents per pound)

	1993	1994
Trioxide, Mexican	33	32
Metal, Chinese	44	40

Source: Calculated from Bureau of the Census import data.

TABLE 4
ARSENIC TRIOXIDE: 1/ WORLD PRODUCTION, BY COUNTRY 2/ 3/

(Metric tons)

Country 4/	1990	1991	1992	1993	1994 e/
Belgium e/	3,000	2,500	2,000	2,000	2,000
Bolivia	300	463	633	663 r/	670
Canada	485	236	250 e/	250 e/	250
Chile	5,830	6,820	6,020	6,200 e/	6,300
China e/	9,000	10,000	14,000	13,000	13,000
France e/	6,480	2,000	2,000	3,000 r/	6,000
Georgia e/	XX	XX	1,500	1,000	500
Germany e/ 5/	360	300	300	300	300
Ghana e/ 6/	--	500	500 r/	500 r/	500
Iran	382	552	492	500 e/	500
Japan e/	500	500	500	500	500
Kazakhstan e/	XX	XX	2,000	2,000	1,500
Mexico	4,810	4,920	4,290	4,450 r/	4,400
Namibia 7/	1,640	1,800	2,460	2,290 r/	2,300
Peru 8/	500 e/	661	607	610 e/	610
Philippines e/	5,090 9/	5,000	5,000	2,000	2,000
Portugal e/	200	200	150	150	150
Russia e/	XX	XX	2,500 r/	2,000	1,500
Sweden e/ 10/	7,000	2,500	--	--	--
U.S.S.R. e/ 11/	7,800	7,000	XX	XX	XX
Total	53,400	46,000	45,200 r/	41,400 r/	43,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Including calculated arsenic trioxide equivalent of output of elemental arsenic and arsenic compounds other than arsenic trioxide where inclusion of such materials would not duplicate reported arsenic trioxide production.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Table includes data available through Apr. 4, 1995.

4/ Austria, Hungary, the Republic of Korea, the Republic of South Africa, Spain, the United Kingdom, and former Yugoslavia have produced arsenic and/or arsenic compounds in previous years, but information is inadequate to make reliable estimates of output levels, if any.

5/ All production for Germany in 1990 came from the former Western states.

6/ Byproduct of gold ore roasting. Does not include production of significant quantities of noncommercial grade material estimated at 4,000 tons in 1992, 9,000 tons in 1993, and 9,000 tons in 1994.

7/ Output of Tsumeb Corp. Ltd. only.

8/ Output of Empresa Minera del Centro del Perú (Centromín Perú) as reported by the Ministerio de Energía y Minas.

9/ Reported figure.

10/ Based on arsenic trioxide exported plus the arsenic trioxide equivalent of the output of metallic arsenic exported.

11/ Dissolved in Dec. 1991.

ASBESTOS

By Robert L. Virta

Asbestos is a generic name given to six fibrous minerals that have been used widely in commercial products. The six types of asbestos are chrysotile, crocidolite, amosite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos. The most widely used variety is chrysotile. The properties that make asbestos so versatile and cost effective are high tensile strength, chemical and thermal stability, high flexibility, low electrical conductivity, and large surface area.

Domestic production data for asbestos were collected by means of a voluntary survey of two mining operations. Both operations responded, representing 100% of the total sales data shown in table 1.

Legislation and Government Programs

The Mine Safety and Health Administration continued reviewing its proposed revisions to existing standards for air quality and chemical substances, including the lowering of permissible exposure levels to asbestos from 2.0 fibers per cubic centimeter to 0.2 fibers per cubic centimeter.[1]

The Environmental Protection Agency (EPA) proposed to amend its Worker Protection Rule for asbestos abatement projects. The proposed change would incorporate asbestos workplace standards developed by the Occupational Safety and Health Administration (OSHA) and extend coverage to include State and local workers not covered by EPA or OSHA asbestos abatement plans. The proposed rule also would amend the Asbestos Hazard Emergency Response Act.[2]

EPA issued a ruling that specifies the types of roof removal operations that are covered by the National Emission Standards for Hazardous Air Pollutants (NESHAP) and roof removal work practices that are in compliance with the NESHAP.[3]

OSHA amended its standards for occupational exposure to asbestos in general industry and the construction industry. The time-weighted-average permissible exposure limit for asbestos was reduced from 0.2 fiber per cubic centimeter to 0.1 fiber per cubic centimeter in all industries. The rule includes a new job classification scheme for construction and shipyard work, an asbestos identification requirement for asbestos containing building materials, notification requirements for abatement work, and control methods for brake and clutch repairs.[4]

A wide variety of asbestos-containing civilian products also have military applications. Examples include friction materials (brakes and clutches), electrical and thermal insulations, packings and gaskets, asbestos-reinforced plastics, etc., for use on military vehicles, ships, rockets, missiles, and in military construction. Consumption of asbestos, however, has decreased considerably in recent years because of the controversy surrounding exposures to asbestos dust. Because of the trend toward lower asbestos consumption, the Department of Defense authorized the disposal of 9,770 tons of chrysotile, 30,900 tons of amosite, and 33 tons of crocidolite from the National Defense Stockpile.

Production

Asbestos was mined in the United States by one company, KCAC Inc., San Benito County, CA. Domestic production was limited to chrysotile, one of six commercial varieties of asbestos. KCAC operated a mine in a highly sheared serpentinite composed of matted, short fiber chrysotile and unfractured serpentinite (also referred to as a mass fiber deposit). The ore was stripped, and wet processing was used to beneficiate the fiber. Vermont Asbestos Group Inc., Orleans County, VT, sold asbestos fiber from inventory. While the California company produced only short fiber chrysotile, the Vermont company produced a wide range of chrysotile grades.

Domestic production (sales) declined from 13.7 thousand tons in 1993 to 10.1 thousand tons in 1994. *(See table 1.)*

Consumption

U.S. consumption of asbestos decreased from 31.6 thousand tons in 1993 to 26.8 thousand tons in 1994. Reported consumption declined in most industry segments. The two largest consumers of asbestos were the roofing products and friction products industries with 47% and 35% of the market, respectively.

More than 99% of the asbestos consumed domestically was chrysotile. The remainder was crocidolite. Ninety-two percent of the chrysotile consumed in the United States was grade 7, followed by grades 5, 4, 6, and 3. *(See table 2.)*

Manufacturers gradually have been replacing asbestos with substitute materials, redesigning old products to eliminate the need for asbestos, or designing new products that require neither asbestos nor asbestos substitutes. Economic, manufacturing, performance, and/or technical difficulties were considered before asbestos was replaced by a substitute material or product.

Examples of materials substituted for asbestos include aramid fiber, carbon fiber, cellulose fiber, ceramic fiber, fibrous glass, several varieties of organic fiber, steel fibers, and wollastonite. Examples of alternative products include aluminum, vinyl, and wood siding; aluminum and fiberglass sheet; asphalt coatings; ductile iron pipe; polyvinylchloride pipe; prestressed and reinforced concrete pipe, and semimetallic brakes.

Prices

The average unit value of domestically produced asbestos increased from $435 per ton in 1993 to $506 per ton in 1994. The increase was attributed to increased sales of higher value fiber in 1994 compared to 1993. Unit values for all varieties of imported asbestos ranged from $177 per ton to $3,401 per ton and averaged $209 per ton. Unit values for all varieties of exported asbestos ranged from $192 per ton to $5,380 per ton and averaged $375 per ton.

The customs unit value for imported chrysotile ranged from $177 per ton to $3,401 per ton. The customs unit value for imported crude chrysotile was $741 per ton. This is comparable to the unit values of the early 1990's. The high unit value in 1993 was the result of a single shipment of a high-value fiber. The unit value for spinning grade chrysotile increased in 1993 and the unit value for other chrysotile types declined. The customs unit value for imported crocidolite was reported to be $369 per ton. This is considerably lower than in previous years. Based on the lack of any significant markets in the United States, the source of the asbestos listed under the crocidolite category (Canada), and the low unit value, imports reported as crocidolite probably should have been reported as chrysotile. *(See tables 3 and 6.)*

Approximate equivalents, in dollars per metric ton, of price ranges quoted in Industrial Minerals (London), December 1994, for Canadian chrysotile, f.o.b. mine, ranged between $210 per ton and $1,750 per ton, depending on the grade. Crocidolite from the Republic of South Africa ranged from $640 per ton to $920 per ton, depending on the grade. Quoted prices should be used only as a guideline because actual prices depend on the terms of the contract between seller and buyer.

Foreign Trade

The total value of asbestos fibers and asbestos products exported and reexported increased in 1994. Canada was the largest importer of unmanufactured fibers and manufactured products from the United States, followed by Mexico and Japan. *(See table 4.)* The largest increase in export value was observed under the brake and clutch lining categories. *(See table 5.)* It is likely that nonasbestos products (products based on cellulose, magnesium carbonate, or other minerals) included under the asbestos export codes contributed to this increase in export values based on the slight decrease in domestic asbestos consumption for these products in 1994. Exports and reexports of brake linings and disk pads accounted for 84% of the value of all manufactured asbestos products.

The Bureau of the Census reported that 17,500 tons of asbestos were exported in 1994. This category includes asbestos crudes, stucco, sand, and refuse as well as asbestos fiber. It is likely that some manufactured asbestos products, nonasbestos fiber, and/or nonasbestos mineral exports also were included in the export total. Exports of asbestos fiber were reported to be slightly less than 10,000 tons by domestic producers in 1994.

Canada supplied nearly all of the asbestos imported into the United States and most of the asbestos fiber imported into the United States was chrysotile. *(See table 6.)* According to the Bureau of the Census, 242 tons of asbestos imports were reported as crocidolite in 1994. Markets for crocidolite, however, are very limited and consumption was estimated to be less than one ton. Asbestos imports reported as crocidolite probably were chrysotile based on the source (Canada) and the unit value of the shipments ($369 per ton). Asbestos under the "Other" category in table 6 was imported from Canada and assumed to be chrysotile.

World Review

World production of asbestos was estimated by the U.S. Bureau of Mines (USBM) to be 2.41 million tons. The Department of Natural Resources Canada (DNR), however, estimated world production to be 2.74 million tons. The difference between the two numbers occurred because the USBM estimated production for the Commonwealth of Independent States (CIS) to be 1.1 million tons and DNR estimated production to be 1.4 million tons. Despite the difference in the estimates for the CIS, Russia continued to be the largest producer of asbestos, followed by Canada, Kazakhastan, and China. Canada, Kazakhastan, and Russia accounted for approximately 67% of the world production. *(See table 7.)*

Outlook

World production has declined to approximately 50% of that of the late 1970's. The decline was largely in response to the opposition to the use of asbestos in consumer and building products. Opposition to the use of asbestos will continue to affect world demand although its impact will not be as great as in previous years. World production probably will decline but at a much lower rate than was observed between 1989 and 1994.

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[1] Federal Register. Mine Safety and Health Administration. Air Quality, Chemical Substances, and Respiratory Protection Standards. V. 56, No. 39, Feb. 27, 1991, pp. 8168-8171.

[2] ———. Environmental Protection Agency. Asbestos Worker Protection; Asbestos-Containing Materials in Schools; Proposed Amendment. V. 59, No. 210, Nov. 1, 1994, pp. 54746-54779.

[3] ———. Environmental Protection Agency. Interpretive Rule for Roof Removal Operations Under the Asbestos NESHAP. V. 59, No. 116, June 17, 1994, pp. 31157-31161.

[4] ———. Occupational Safety and Health Administration. Occupational Exposure to Asbestos. V. 59, No. 153, Aug. 10, 1994, pp. 40964-41162.

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TABLE 1
SALIENT ASBESTOS STATISTICS 1/
(Metric tons unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production (sales):					
Quantity	W	20,100	15,600	13,700	10,100
Value 2/ thousands	W	$7,690	$6,140	$5,960	$5,120
Exports and reexports 3/ (unmanufactured):					
Value thousands	$7,960	$7,420	$6,720	$8,440	$6,550
Exports and reexports of asbestos products:					
Value thousands	$120,000	$116,000	$134,000	$141,000	$177,000
Imports for consumption 4/ (unmanufactured):					
Quantity	41,300	34,800	31,600	30,800	25,800
Value thousands	$10,800	$8,900	$7,210	$6,960	$5,390
Consumption, apparent 5/	41,300	34,800	32,800	31,600	26,800
World: Production	4,010,000 r/ 6/	3,490,000 r/	3,320,000 r/	2,650,000 r/	2,410,000 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ F.o.b. mine.

3/ F.A.S. value, includes exports of crudes, fibers, stucco, sand, and refuse. May also include nonasbestos materials.

4/ U.S. Customs declared value.

5/ Production, plus imports, minus producer exports of asbestos fiber, plus adjustments in Government and industry stocks.

6/ Does not include U.S. production.

TABLE 2
U.S. ASBESTOS CONSUMPTION BY END USE, GRADE, AND TYPE 1/ 2/
(Metric tons)

	Chrysotile							
End use	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total	Crocidolite	Total Asbestos
1993 total	158	1,080	1,680	460	28,200	31,600	18	31,600
1994:								
Coatings and compounds	--	--	--	--	290	290	--	290
Friction products	8	--	521	268	8,660	9,460	--	9,460
Packing	1	25	284	96	2,350	2,750	--	2,750
Paper	--	--	--	--	270	270	--	270
Plastics	39	--	--	--	52	91	--	91
Roofing products	--	8	--	--	12,600	12,600	--	12,600
Other	276	582	59	--	457	1,370	--	1,370
Total	324	615	864	364	24,700	26,800	(3/)	26,800

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Estimated distribution based upon data provided by the Asbestos Institute, Montreal, Canada, and the U.S. Bureau of Mines asbestos producer survey.

3/ May include imports of chrysotile. Estimated consumption of crocidolite was less than one ton.

TABLE 3
CUSTOMS UNIT VALUES OF IMPORTED ASBESTOS
(Dollars per metric ton)

	1993	1994
Canada:		
Chrysotile:		
Crude	1,519	741
Spinning	350	410
Other	224	198
South Africa, Republic of:		
Amosite	--	--
Crocidolite	--	369 1/

1/ May include imports of chrysotile.

Source: Bureau of the Census.

TABLE 4
U.S. EXPORTS AND REEXPORTS OF ASBESTOS FIBERS AND PRODUCTS 1/ 2/
(Thousand dollars)

Country	1993			1994		
	Unmanufactured fiber 3/	Manufactured products 4/	Total	Unmanufactured fiber 3/	Manufactured products 4/	Total
Australia	21	865	887	24	1,250	1,270
Brazil	600	515	1,120	658	1,880	2,540
Canada	289	84,700	85,000	282	105,000	106,000
Germany	--	4,560	4,560	16	4,200	4,210
Japan	3,350	11,100	14,400	2,940	9,790	12,700
Korea, Republic of	313	2,140	2,460	135	2,050	2,190
Kuwait	91	69	160	--	115	115
Mexico	605	9,630	10,200	543	12,800	13,300
Saudi Arabia	142	1,010	1,150	142	506	648
Thailand	255	637	892	363	420	783
Turkey	--	529	529	--	140	140
United Kingdom	--	2,340	2,340	--	3,310	3,310
Venezuela	--	489	489	--	363	363
Other	2,770	22,500	25,200	1,450	35,200	36,600
Total	8,440	141,000	150,000	6,550	177,000	184,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ F.A.S. value.

3/ Includes exports of crudes, fibers, stucco, sand, and refuse. May also include nonasbestos materials.

4/ Also includes products manufactured using asbestos substitutes.

Source: Bureau of the Census.

TABLE 5
U.S. EXPORTS AND REEXPORTS OF ASBESTOS AND ASBESTOS PRODUCTS 1/

	1993		1994	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Unmanufactured:				
Asbestos 3/	27,600	$8,440	17,500	$6,550
Manufactured:				
Asbestos fibers	NA	723	NA	746
Brake linings and disk brake pads 4/	NA	114,000	NA	149,000
Clutch facings and linings 5/	NA	7,190	NA	9,270
Clothing, cord, fabric, and yarn	NA	1,410	NA	2,670
Gaskets, packing and seals	NA	4,660	NA	3,130
Panel, sheet, tile, and tube 6/	NA	6,430	NA	5,150
Paper and millboard	NA	947	NA	873
Other articles 7/	NA	6,130	NA	6,030
Total	XX	141,000	XX	177,000

NA Not available. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ F.A.S. value.

3/ Includes crudes, fibers, stucco, sand, and refuse. May also include nonasbestos materials.

4/ Includes asbestos and cellulose fiber brakes and similar materials.

5/ Includes clutches and other friction materials, excluding brakes and brake pads.

6/ Includes asbestos cement and cellulose fiber cement products.

7/ Includes asbestos and cellulose fiber products.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF ASBESTOS FIBERS, BY TYPE, ORIGIN, AND VALUE 1/ 2/

	Canada		South Africa, Republic of		Other		Total	
Type	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
Chrysotile:								
Crude	16	24	--	--	--	--	16	24
Spinning fibers	935	267	--	--	43	75	978	342
All other	26,600	5,830	--	--	88	152	26,700	5,980
Crocidolite (blue) 3/	18	4	--	--	--	--	18	4
Other (unspecified asbestos type)	3,100	604	--	--	--	--	3,100	604
Total	30,700	6,730	--	--	131	227	30,800	6,960
1994:								
Chrysotile:								
Crude	101	73	--	--	28	22	129	96
Spinning fibers	752	228	--	--	35	94	787	323
All other	22,200	4,280	--	--	8	15	22,200	4,290
Crocidolite (blue) 3/	242	89	--	--	--	--	242	89
Other (unspecified asbestos type)	2,430	575	--	--	14	8	2,440	583
Total	25,700	5,250	--	--	85	140	25,800	5,390

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ U.S. Customs declared value.

3/ Reported by the Bureau of the Census. Its source and low value suggest the imports labeled as crocidolite were primarily chrysotile.

Source: Bureau of the Census.

TABLE 7
ASBESTOS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina	275	270	215 r/	309 r/	350
Bosnia and Herzegovina e/ 4/	XX	XX	500	500	300
Brazil	205,000	237,000 e/	170,000 r/	175,000 r/	175,000
Bulgaria	500	400	500 r/ e/	400	400
Canada	725,000 r/	639,000	591,000	517,000 r/	518,000
China e/	221,000	200,000	240,000	240,000	240,000
Colombia	8,000 e/	7,830 r/	7,900	8,000	7,500
Egypt	369	450	373	436 r/	400
Greece	66,000 r/	4,730	--	--	--
India	26,100 r/	24,100 r/	43,700 r/	43,600 r/	44,000
Iran e/	2,800	3,000	4,300	4,500	4,500
Italy	3,860	15,000 e/	--	--	--
Japan e/	5,000	25,000	29,500	24,900 r/	25,000
Kazakhstan e/	XX	XX	400,000 r/	325,000 r/	300,000
Korea, Republic of	1,530	1,500 e/	2,310 r/	2,200	2,000
Russia e/	XX	XX	1,500,000	1,000,000	800,000
Serbia and Montenegro 4/	XX	XX	1,180	1,100 e/	1,100
South Africa, Republic of	146,000 r/	149,000 r/	133,000	104,000 r/	94,800 5/
Swaziland	35,900	13,900 r/	32,300	33,900 r/	35,000
U.S.S.R. e/ 6/	2,400,000	2,000,000	XX	XX	XX
United States (sold or used by producers)	W	20,100 r/	15,600 r/	13,700	10,100 5/
Yugoslavia 4/ 7/	6,580 r/	6,170 r/	XX	XX	XX
Zimbabwe	161,000 r/	142,000 r/	150,000	157,000 r/	150,000
Total	4,010,000	3,490,000 r/	3,320,000 r/	2,650,000 r/	2,410,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Marketable fiber production. Table includes data available through Apr. 18, 1995.

3/ In addition to the countries listed, Afghanistan, North Korea, Romania, and Slovakia also produce asbestos, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.

4/ All production from Yugoslavia in 1991 came from Bosnia and Herzegovina and Serbia and Montenegro.

5/ Reported figure.

6/ Dissolved in Dec. 1991.

7/ Dissolved in Apr. 1992.

BARITE

By James P. Searls

The term "primary barite," as used in this report, refers to the first marketable product. This product includes crude barite, and the product of simple beneficiation methods such as washing, jigging, heavy media separation, tabling, flotation, and magnetic separation. Most primary barite requires grinding to a small, uniform size before it is used as a weighting agent in petroleum well drilling mud or as an addition to industrial products. This grinding was not usually performed at the mine site because railroad tariffs were higher for finished barite than for crude barite. There was some grinding of barite at the mine sites in Nevada to supply Western States, western Canadian provinces, and Alaska.

Barite is the mineralogical name for barium sulfate and was derived from the Greek word "barus," meaning heavy. In commerce, the mineral is sometimes referred to as "heavy spar" or "barytes." "Spar" means almost any transparent or translucent, readily cleavable, crystalline mineral having a vitreous luster.[1] One domestic barite producer has named its white technical grade barite as "baryte" to distinguish it from the petroleum well drilling [American Petroleum Institute (API) or Oil Companies' Materials Association (OCMA)] specification barite. Few mines in the United States produce a "spar" grade barite. Barite for petroleum well drilling, a weighting agent in the drilling mud, can be any color but must be only finely ground, dense, soft, and chemically inert. Barite for this purpose must have a specific gravity of 4.2 or greater, be free of soluble salts, and 90% to 95% of the material must pass through a 325-mesh screen. A small percentage of iron oxide is not allowable. Petroleum well drilling barite sales averages about 90% of total sales by processors, and it can be blue, black, brown, or gray depending on the ore body.

Production

The quantity of primary barite sold or used by producers rose for a second year even though the data in table 1 does not reflect the fact. In 1993, data for run-of-mine barite were withheld to comply with regulations protecting company proprietary data. In 1994, there were more than three sellers, and a large increase of total sales and run-of-mine sales are reported.

The 1994 level of total barite sales was above all preceding years since 1985 and equaled about 87% of 1985's total sales tonnage. *(See table 2.)*

Domestic sales data for barite were developed by the U.S. Bureau of Mines (USBM) from a voluntary survey of U.S. operations. Of the 37 operations to which a survey was sent, all reported, representing 100% of the primary barite, sold or used by producers. Of the 37 operations surveyed, there were 15 mines. One mine had closed during the year, 3 were idle, and 11 were producing. There were 22 grinding plants that were surveyed; 2 had closed, 1 was idle, and 19 were operating. *(See table 3.)* M-I Drilling Fluids' Clipper Mine was closed in 1994 owing to lack of demand. In 1993 and 1994, Baroid's Lakes Mine, Standard Slag's P&S Mine, and Milpark's Miller Mine were idle. M-I Drilling Fluids' New Orleans and West Lake grinding plants were closed in 1994. In 1993 American Minerals' Grinding Mill, Clark Minerals' Diana Mill, M-I's Brownsville plant, and Old Soldier's Elk City Mill were closed. In 1993 and 1994, Standard Magnesia's Fallon Mill was idle.

Dresser Industries, Inc. acquired Baroid Corp. in January. Dresser then was required by the Anti-Trust Division of the U.S. Department of Justice to sell within 6 months, and did sell, its 64% control of M-I Drilling Fluids Co. to Smith International Inc. The other holder of M-I Drilling Fluids Co., Haliburton Energy Services, retained its 36% ownership through the transaction.

Sales have risen from the 1992 low of 326,000 metric tons to 583,000 tons in 1994. More producers reported run-of-mine sales for 1994. Beneficiated product was 62% of total sales in 1994, while in 1992 the beneficiated product was 96% of total sales. The sales of industrial barite rose by 25% between 1993 and 1994 while the sales of barite for petroleum well weighting rose 14%. *(See table 4.)*

Prices

The nominal average weighted price for sales of all barite by U.S. producers rose from \$37.21 per ton in 1990 to \$61.27 per ton in 1993 and dropped back to \$37.22 per ton in 1994. This variation in prices was due to the shift towards industrial barite by domestic producers between 1990 and 1993 as low-cost, high-purity, but off-color Chinese and Indian barite became readily available. Demand for petroleum well weighting barite has been increasing over 1993 and 1994 owing to deep gas well drilling off the coast of Louisiana and Texas. Production and quality problems developed in late 1993 in both China and India, which resulted in reduced exports to the Gulf Coast. Prices for petroleum well weighting barite rose owing to imports into the Gulf States not rising as fast as demand, which allowed Nevada produced barite to return to the market. For 1994, the domestic producers supplied a broader range of barite quality, excluding only the United States Pharmacopoeia barite.

Nominal average prices for the crushed and ground barite rose from \$69.65 per ton in 1990 to \$84.48 per ton in 1992 and declined to \$62.26 per ton in 1994. International prices for the middle of the year from Industrial Minerals[2] were as follows: Unground, OCMA/API bulk, specific gravity 4.22, FOB Morocco, \$37-\$40 per ton; Ground, bagged, FOB Morocco, \$85 per ton; Ground OCMA bulk, delivered Aberdeen, \$69.30-\$80.09 (£45-£52)[3] per ton; and Micronised, off white minimum 99% < 20 microns delivered UK, \$215.60-\$231 (£140-£150) per ton.

Consumption

The consumption of industrial barite is not well reported to the USBM. Crushers and grinders report only a division of sales between petroleum well weighting barite and "industrial" barite. No subdivisions of industrial end uses are reported because they are less than approximately 20,000 tons per year.

In 1994, barite demand showed little or no correspondence to the traditional indicators, such as oil price, gas price, increased well drilling, or drilling deeper wells. For the yearend 1994, the week-average futures price for light sweet crude oil had risen by 18.1% to $17.07 per barrel[4] (bbl) relative to $14.45 per bbl at yearend 1993. At midyear, the price was $18.00 per bbl[5] so there was a strong increase in the first half of the year, followed by a significant decrease in the second half of the year. But there were fewer drill rigs directed towards oil prospects or locations in the middle of the year. The natural gas futures price moved in the opposite direction by falling from $2.04 per million British Thermal Units (BTU) to $1.59 per million BTU's, about a 22.1% decrease, on the same basis. The number of gas directed rigs was essentially constant at about 420 rigs through the year,[6] while the number of oil directed rigs went from about 385 rigs at the beginning of 1994 to about 350 rigs at yearend.

Since wells, both oil and gas, start to encounter significantly higher pressures when deeper than about 3,135 meters (m) [7,000 feet (ft)] there should be an increase in barite consumption as more deep wells are drilled. However, wells completed deeper than 1,524 m (5,000 ft) in 1994, decreased 3% from 1993. But the average depth of exploratory and development wells drilled and completed, reported and estimated, according to the API,[7] increased 10% in 1994 from 1,625 m in 1993. Total completed gas wells declined from 9,693 wells, averaging 1,820 m in 1993, to 8,079 wells, averaging 1,890 m, in 1994. These factors would predict a decrease in sales of petroleum well weighting barite, yet sales increased from the previous year. Whatever drove barite consumption in 1994 may not affect the demand again and 1994 may be a high point of barite demand. *(See tables 5, 6, 7, and 8.)*

Outlook

Barite is not likely to increase greatly beyond its present sales level and could decline, given all the negative trends in the 1994 well drilling statistics from the oil and gas industry. Much of the exploratory and development drilling has moved away from the United States owing to the lack of potential large discoveries and the environmental concerns. Barite is found around the world and is not shipped great distances, except by water, because of its relatively high density and low value. If the gas prices in the United States keep dropping, the chances of profits, given the possibilities of dry wells and successes, may become too low to pay back the cost of drilling. Also, the number of large, deep, undiscovered gas reserves, both onshore and offshore, is unpredictable but likely to decline.

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[1] A Dictionary of Mining, Mineral, and Related Terms, P. W. Thrush, Ed., U.S. Department of the Interior, U.S. GPO, Washington, DC, 1968, p. 1049.

[2] Industrial Minerals, (London), No. 322, July 1994, p. 68.

[3] International Monetary Fund, International Financial Statistics, End of June 1994, $1.4484/SDR, £0.94038/SDR, Feb. 1995, p. 6.

[4] The Oil & Gas Journal, PennWell Publishing Co., Tulsa, OK, v. 93, No. 2, Jan. 9, 1995, p. 3.

[5] ———. V. 92, No. 28, July 11, 1994, p. 3.

[6] ———. V. 92 No. 2, Jan. 10, 1994, p. 66.

[7] American Petroleum Institute, Quarterly Completion Report-Fourth Quarter, 1994, V. X, No. 4, Jan, 1995. pp. 2-6.

TABLE 1
SALIENT BARITE AND BARIUM CHEMICAL STATISTICS 1/ 2/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Barite, primary:					
Sold or used by producers	430	448	326	315 3/	583
Value	$16,000	$21,300	$19,600	$19,300 3/	$21,700
Exports	9	43	12	18	14
Value	$1,680	$3,300	$1,810	$2,610	$1,850
Imports for consumption 4/	1,050 r/	887 r/	354 r/	804 r/	1,070
Value	$46,300 r/	$41,300 r/	$17,300 r/	$34,200 r/	$47,200
Consumption (apparent) 5/	1,470 r/	1,290 r/	668 r/	1,100 r/	1,640
Crushed and ground (sold or used by processors) 6/	1,430	1,270	999	1,090 r/	1,250
Value	$99,600	$103,000	$84,400	$79,200 r/	$81,100
World: Production	5,770 r/	5,470 r/	4,630 r/	4,080 r/	4,470 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits.

2/ Barium chemicals data withheld to avoid disclosing company proprietary data.

3/ Data excludes run of mine.

4/ Includes crude and ground.

5/ Sold or used plus imports minus exports.

6/ Includes imports.

TABLE 2
U.S. PRIMARY BARITE SOLD OR USED BY PRODUCERS, BY STATE 1/

State	Number of operations	Run of mine		Beneficiated material 2/		Total	
		Quantity (thousand metric tons)	Value (thousands)	Quantity (thousand metric tons)	Value (thousands)	Quantity (thousand metric tons)	Value (thousands)
1993:							
Nevada	5	W	W	242	$9,100	242 3/	$9,100
Other States	5	--	--	73	10,200	73 3/	10,200
Total	10	W	W	315	19,300	315 3/	19,300
1994:							
Nevada	5	W	W	284	5,020	284 3/	5,020
Other States	6	W	W	77	10,800	77 3/	10,800
Total	11	222	$5,930	361	15,800	583	21,700

W Withheld to avoid disclosing company proprietary data; included in "Total".

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes flotation concentrate.

3/ Data excludes run of mine.

TABLE 3
CRUSHED AND GROUND BARITE SOLD OR USED BY PROCESSORS IN THE UNITED STATES, BY STATE 1/ 2/

State	1993			1994		
	Number of plants	Quantity (thousand metric tons)	Value (thousands)	Number of plants	Quantity (thousand metric tons)	Value (thousands)
Louisiana	7	534	$37,000	5	676	$51,700
Nevada	5 r/	212 r/	9,310 r/	4	308	7,220
Other 3/	13 r/	341	32,900	10	266	22,179
Total	25 r/	1,090 r/	79,200 r/	19	1,250	81,100

r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes imports.

3/ Includes California, Georgia, Illinois, Missouri, New York (1994), Oklahoma (1993), Texas, and Utah.

TABLE 4
CRUSHED AND GROUND BARITE SOLD OR USED BY PROCESSORS IN THE UNITED STATES, BY USE 1/ 2/

(Thousand metric tons and thousand dollars)

Use	1993		1994	
	Quantity	Value	Quantity	Value
Barium chemicals, filler and/or extender, glass	104	$17,000	130	$18,700
Well drilling	984 r/	62,200 r/	1,120	62,400
Total	1,090 r/	79,200 r/	1,250	81,100

r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes imports.

TABLE 5
U.S. EXPORTS OF NATURAL BARIUM SULFATE (BARITE), BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	--	--	19	$3
Barbados	--	--	90	48
Canada	9,120	$1,180	11,700	1,120
Dominican Republic	--	--	23	9
Honduras	3	3	--	--
Italy	14	3	28	14
Japan	118	604	43	207
Korea, Republic of	6	13	36	15
Mexico	1,040	262	1,870	408
Panama	150	20	--	--
Spain	20	65	--	--
Trinidad and Tobago	9	4	--	--
Tunisia	3	35	--	--
United Kingdom	2	4	19	19
Venezuela	8,000	412	--	--
Total	18,500	2,610	13,800	1,850

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF BARITE, BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Crude barite:				
Canada	144	$24	321	$67
China	419,000	17,100	788,000	33,000
India	271,000	8,920	198,000	5,980
Mexico	36,000	1,370	2,390	217
Morocco	--	--	26,300	1,110
Switzerland	39,400	1,450	--	--
Total	766,000	28,900	1,020,000	40,400
Ground barite:				
Canada	10,200	2,730	11,600	2,730
Denmark	5	3	7	4
Germany	147	69	189	92
Japan	8	21	106	60
Mexico	27,400	2,460	46,600	3,920
Netherlands	24	12	2	3
Total	37,800	5,290	58,500	6,810

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ C.i.f. value.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF BARIUM CHEMICALS 1/

Year	Barium choride		Barium oxide, hydroxide, and peroxide	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
1993	487	$275	4,590	$5,020
1994	510	264	4,240	4,640
	Barium nitrate		Barium carbonate, precipitated	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
1993	2,170	2,150	10,900	6,370
1994	2,800	2,510	18,700	10,600
	Other barium compounds			
	Quantity (metric tons)	Value 2/ (thousands)		
1993	12,200	10,700		
1994	13,000	11,400		

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits.
2/ C.i.f. value.

Source: Bureau of the Census.

TABLE 8
BARITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Afghanistan e/ 4/	2,000	2,000	2,000	2,000	2,000
Algeria	53,100	44,400	45,000	45,000 e/	45,000
Argentina	40,100 r/	23,900 r/	10,000 r/	11,300 r/	11,500
Australia e/	11,000	11,000	11,000	11,000	11,000
Belgium e/	35,000	35,000	30,000	30,000	30,000
Bolivia	300	1,280	368	-- e/	3,310 5/
Bosnia and Herzegovina e/ 6/ 7/	XX	XX	3,000	2,000	1,000
Brazil (beneficiated)	55,600	46,800	54,500	32,100 r/	45,000
Burma e/ 8/	9,470 5/	11,400 r/	13,600 r/	15,600 r/	16,000
Canada	41,000	50,000	37,000	59,000	55,000 5/
Chile	3,040	3,180	2,510 r/	2,040 r/	2,400
China e/	1,750,000	1,600,000 r/	1,500,000 r/	1,500,000 r/	1,500,000
Colombia	5,380	9,290	9,380	4,840 r/	7,000
Croatia e/ 7/	XX	XX	1,500	1,500	1,000
Czechoslovakia 9/	88,000	86,000 e/	31,300	XX	XX
Egypt	6,200	5,940	5,900 e/	5,900 e/	5,900
France	92,500	90,000 e/	96,200	67,200 r/	70,000
Georgia e/	XX	XX	40,000	30,000	20,000
Germany:					
Eastern states	61,400	XX	XX	XX	XX
Western states	148,000 r/	XX	XX	XX	XX
Total	209,000 r/	164,000	157,000	131,000 r/	135,000
Greece (crude ore)	1,620	1,310	1,000 e/	1,000 e/	1,000
Guatemala	421	--	1,720 r/	1,500 e/	1,000
India	633,000	615,000	458,000 r/	507,000 r/	510,000
Iran 4/	77,400	191,000	181,000	105,000 r/	100,000
Ireland	101,000	94,300	70,600	53,000 r/ e/	60,000
Italy	44,300	88,500	74,900	52,000 r/ e/	60,000
Kazakhstan e/	XX	XX	200,000	200,000	150,000
Kenya e/	105 5/	100	100	100	100
Korea, Republic of	2,920	1,010	40	50 e/	50
Malaysia	48,300	16,600	10,500	11,600 r/	17,100 5/
Mexico	306,000	192,000	188,000	136,000 r/	150,000
Morocco	364,000	433,000	401,000	325,000	265,000 5/
Pakistan	23,300	28,800	32,400	26,300 r/	25,000
Peru	130,000 e/	150,000	16,600	16,600 e/	17,000
Philippines e/	500	500	500	500	500
Poland	25,300	18,300	15,700	16,000 e/	16,000
Portugal e/	1,220	1,000 r/	378 r/ 5/	350 r/	300
Romania e/	65,000	70,000	118,000 5/	115,000	105,000 5/
Slovakia e/	XX	XX	XX	30,000	25,000
South Africa, Republic of	2,490	4,790	3,570	2,000 r/	1,800 5/
Spain e/	11,300 5/	9,000	10,000	6,000 r/	5,000
Thailand	108,000	93,000 r/	46,300	42,400 r/	49,200
Tunisia	30,900	22,400	30,200	30,000 e/	30,000
Turkey (run of mine)	367,000	251,000	311,000	121,000 r/	140,000
U.S.S.R. e/ 10/	500,000	450,000	XX	XX	XX
United Kingdom	67,600	85,500	76,700	32,600 r/	40,000
United States 11/	430,000	448,000	326,000	315,000 12/	758,000 5/
Yugoslavia 6/ 7/ 13/	23,600	20,000 e/	XX	XX	XX
Zimbabwe	320	866	232	120 r/	120
Total	5,770,000 r/	5,470,000 r/	4,630,000 r/	4,080,000 r/	4,470,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 6, 1995.

3/ In addition to the countries listed, Bulgaria also produces barite, but available information is inadequate to make reliable estimates of output levels.

4/ Data are for fiscal year beginning Mar. 21 of that stated.

5/ Reported figure.

6/ All production in Yugoslavia from 1990-91 came from Bosnia and Herzegovina.

7/ Barite concentrates.

8/ Data are for fiscal year beginning Apr. 1 of that stated.

9/ Dissolved Dec. 31, 1992. Production in Czechoslovakia from 1990-91 came from the Czech Republic and Slovakia; all production for 1992 came from Slovakia.

10/ Dissolved in Dec. 1991.

11/ Sold or used by producers.

12/ Data excludes run-of-mine.

13/ Dissolved in Apr. 1992.

BAUXITE AND ALUMINA

By Errol D. Sehnke

Total world output of bauxite and alumina decreased during 1994, owing to a market oriented cutback in the worldwide production of primary aluminum metal, with bauxite production dropping by approximately 1% and alumina output decreasing by 3%. Mine production of bauxite was reported from 27 countries. Alumina reportedly was produced in 29 countries around the world.

U.S. mine production of bauxite increased in 1994; nevertheless, imports continued to dominate the domestic market. In 1994, U.S. bauxite mine production once again amounted to less than 1% of total world production, and this domestic output was used exclusively for nonmetal applications. U.S. consumption of bauxite in 1994 dropped by about 2% below 1993 consumption levels. This downturn in domestic consumption was felt across all industrial sectors. Similarly, demand for alumina remained sluggish throughout the year, mainly in response to reduced primary aluminum smelter operating levels. U.S. production of smelter-grade alumina in 1994 decreased by 10% and shipments from domestic production facilities likewise declined by a similar amount. This decrease in U.S. production and shipments of alumina, in combination with a decline in imports for consumption of alumina into the United States, resulted in an approximately 1.2 million metric ton drop in domestic alumina supply compared with 1993.

Identified world bauxite resources (reserves plus subeconomic and undiscovered deposits) at yearend 1994 were estimated by the U.S. Geological Survey to be 55 to 75 billion tons, located in South America (33%), Africa (27%), Asia (17%), Oceania (13%), and elsewhere (10%). The reserve base was estimated by the U.S. Bureau of Mines (USBM) at 28 billion tons and reserves at 23 billion tons. (See table 1.)

Legislation and Government Programs

There were no additions of bauxite to the National Defense Stockpile (NDS) in 1994. In September 1994, the Defense Logistics Agency (DLA) released its new Annual Materials Plan (AMP) for fiscal year 1995. The new AMP, which went into effect on October 1, 1994, provided for the sale of 900,000 long dry tons (915,000 metric dry tons) of metallurgical-grade bauxite; 600,000 long dry tons (610,000 metric dry tons) of Jamaica type; and 300,000 long dry tons (305,000 metric dry tons) of Suriname type. Additionally, as a part of this program, the DLA was authorized to dispose of 80,000 long calcined tons (81,000 metric calcined tons) of refractory-grade bauxite in fiscal year 1995. These were the maximum amounts recommended for disposal during the fiscal year, and the actual level of sales were dependent upon prevailing market conditions. Under provisions of this new AMP, DLA announced plans to issue a consolidated long-term solicitation for a group of eight commodities, including 50,000 long calcined tons (51,000 metric calcined tons) of refractory-grade bauxite.

At yearend 1994, Stockpile holdings for metallurgical-grade bauxite were: 11.6 million tons of Jamaica-type and 5.0 million tons of Suriname-type, with both amounts authorized by the Congress for ultimate disposal. The NDS calcined refractory-grade bauxite inventory was listed as 228,000 tons, with 154,000 tons authorized for ultimate disposal.

Production

U.S. bauxite production approximately doubled in 1994. Nevertheless, it once again amounted to less than 1% of total world production, and was used exclusively for nonmetal products such as abrasives, chemicals, proppants, and refractories. Domestic production and consumption data for bauxite and alumina were obtained by the USBM from three separate, voluntary surveys of U.S. operations. Typical of these quarterly and annual surveys is the "Consumption of Alumina" survey, sent in 1994 to 27 operations, 26 of which responded.

The only active bauxite mines remaining in the U.S. are the surface operations in Alabama and Georgia that produce bauxitic materials, a natural mixture of bauxitic clay and bauxite with a very low iron oxide content, used primarily for the production of alumina calcines. Demand for these domestic ores declined slightly during 1994. Within this market sector, the Harbison-Walker Refractories Division of INDRESCO Inc. shipped bauxite from mines in Alabama to its local calcining plant and to Carbo Ceramic Co.'s proppant plant at Eufaula, AL. Throughout the year, C-E Minerals continued to operate and maintain its mines in Alabama and Georgia, shipping the raw ore to its Andersonville, GA, facility for the production of refractory products.

Annual alumina production from the five Bayer-process alumina plants operating in the United States during 1994 was about 4.9 million tons, a drop of approximately 8% below 1993 output.

In an effort to reduce production costs and improve plant efficiencies, Alcoa's Industrial Chemicals Division announced plans to make a multimillion dollar investment in reengineering its aluminum trihydrate (ATH) production facility at Bauxite, AR. This planned specialty alumina chemical plant modernization scheme involved shortening of facility cycle times, expansion of ATH capacity by more than 25%, and a total upgrade of production efficiency, quality, and consistency. Construction of the modernized facilities was scheduled to begin in late 1994 or early 1995, with the expansion expected to come on-line in late 1995 or early 1996.[1]

Later in 1994, the Aluminum Company of America (Alcoa) and Western Mining Corporation Holdings (WMC) of Australia signed the final agreements to combine their bauxite/alumina and chemical interests into a worldwide joint venture beginning on January 1, 1995. It was expected that the new business enterprise would have annual revenues of nearly $3 billion, with Alcoa owning 60% and WMC 40% of the new enterprise. Alcoa's principal U.S. based alumina and chemical production facilities include its Point Comfort, TX, alumina production plant and specialty alumina chemical facility at Bauxite, AR.

On November 30th, Glencore AG announced that it would temporarily close its Virgin Island Alumina Corp. plant at St. Croix, VI, by yearend. The company indicated it planned to keep the alumina production facility in operational readiness in order that a relatively rapid restart could be achieved once alumina market conditions improved; however, the plant was not expected to reopen for at least 1 year.

As in the past several years, Reynolds Metals Co. indicated that its 1.7-million-ton-per-year capacity Sherwin alumina plant, near Corpus Christi, TX, operated at a reduced production level in 1994. This was a result of the company's effort to balance its alumina supply system with the operation of its U.S. primary aluminum production facilities. At yearend 1994, the Sherwin plant was reported to be operating at 65% of its annual rated capacity. (See tables 2 and 3.)

Consumption

Weak demand for smelter-grade alumina lowered the consumption of crude and dried metallurgical-grade bauxite in 1994. Consumption of bauxite by the abrasive industry decreased by nearly 3% in 1994, consumption by the chemical industry was down by 15%, and use in the refractory industries dropped by 10%. Approximately 93% of the bauxite consumed in the United States during 1994 was refined to alumina, and an estimated average of 2.23 tons of dried bauxite was required to produce 1 ton of calcined alumina. Twenty-two primary aluminum smelters reported a consumption of 6.78 million tons of calcined alumina in 1994, a 9% decrease from the consumption level reported for 1993. This reduced demand resulted in correspondingly lower levels of U.S. alumina production and imports for consumption. Nevertheless, an estimated 90% of the alumina shipped by U.S. alumina plants went to domestic primary smelters for aluminum metal production. Consumption in various forms by the abrasives, chemicals, refractories, and specialties industries accounted for the remainder of the U.S. alumina usage. (See tables 4, 5, 6, and 7.)

Prices

Contract terms for the purchase of metallurgical-gradebauxite and smelter-grade alumina in world markets are not normally made public, and, consequently, contract prices for these commodities are not published by trade journals. Recently, spot or market price estimates for metallurgical-grade alumina have begun to appear in some industry publications, but the majority of published price quotes are limited to certain specialty forms of bauxite and alumina for nonmetallurgical applications.

In 1994, the USBM estimated the average value of domestic crude bauxite shipments, f.o.b. mine or plant, to be $19 per ton. The average value of calcined domestic bauxite was estimated to have once again remained in the $195 to $200 per ton range. Base prices quoted by *Industrial Minerals* magazine and independent sources for imported calcined refractory grade bauxite were as follows: Chinese, minimum 87% alumina (Al_2O_3), f.o.b. Chinese ports, $85 to $95 per ton; Guyanese, f.o.b. rail car, Baltimore, MD, or f.o.b. barge, Gulf Coast, $175 ton. Abrasive grade bauxite, minimum 86% Al_2O_3, c.i.f. main European ports, was priced at $95 to $108 per ton. Base prices were subject to adjustment for various grain-size specifications, size of order, and fuel cost factors.

Surplus levels of alumina supply developed throughout the world, which resulted in spot or market prices for alumina languishing at depressed levels until yearend 1994, when market conditions began to improve. Metallurgical-grade alumina spot prices on international markets ended the year at about the $127 to $130 per ton, which was up somewhat from the lows of $115 to $117 per ton that occurred earlier in the year and well below the high levels previously achieved in the early 1990's. The average value of domestic calcined alumina shipments was estimated to be $184 per ton. Trade data released by the U.S. Bureau of the Census indicated the average value of imported calcined alumina was $182 per ton, f.a.s. port of shipment, and $194 per ton, c.i.f. U.S. ports. Beyond the depressed spot prices of 1994, medium term projections support a reasonably resilient market outlook for alumina toward the close of the 1990's. (See table 8.)

Foreign Trade

Dried bauxite exports from the United States totaled 114,000 tons in 1994, a major increase over the 1993 total of 85,000 tons; Canada received 99% of these 1994 exports. U.S. exports of calcined refractory-grade bauxite totaled 10,500 tons for 1994; Mexico received 44% and Canada 35%. Exports of all other grades of calcined bauxite (chiefly abrasive grade) amounted to 4,490 tons for the year, with Canada receiving 58% of these shipments in 1994. Specialty aluminum compounds exported included 7,060 tons of aluminum sulfate, 11,000 tons of aluminum chloride, 12,700 tons of aluminum oxide abrasives, and 16,100 tons of various fluoride-based compounds of aluminum, including synthetic cryolite and aluminum fluoride.

Imports for consumption of crude and dried bauxite decreased by 8% from the level of 1993 receipts, and the four principal suppliers, Guinea, Jamaica, Brazil, and Guyana, in order of shipments, provided 95% of the total. As in previous years, China and Guyana remained the dominant suppliers of calcined bauxite to the United States. Australia continued to be the primary source of U.S. alumina imports, accounting for slightly more than 65% of the total receipts for 1994. (See tables 9, 10, 11, and 12.)

World Review

World production of bauxite and alumina decreased in response to a market oriented cutback in the worldwide production of primary aluminum metal and a continued flow of aluminum from the republics of the former Soviet Union (FSU) onto the world market. Twenty-seven countries mined bauxite in 1994, and total world production amounted to about 107 million tons, slightly below that mined in 1993. This estimate is based on newly acquired information available following the dissolution of the Eastern bloc and a correspondingly more accurate accounting of total world production of aluminum industry feedstocks. Australia, Guinea, Jamaica, and Brazil, in order of volume, accounted for slightly more than 70% of the total bauxite mined during 1994. The corresponding world output of alumina dropped to 42 million tons, which was about 3% below that of 1993. The four principal producing countries, Australia, the United States, Jamaica, and Russia, in order of volume, supplied approximately 56% of the total world production.

The 1994 world annual rated capacity of plants producing alumina increased by only 3% over the previous year's level, but was nearly 16% above that of 1984. At the same time, apparent worldwide refinery capacity utilization for 1994 was estimated at approximately 85%, a decrease of about 5% from the previous year. As has been the case in recent years, further increases in smelter-grade alumina production capacity are expected to develop principally from incremental expansions of existing plants and only in very special situations from new greenfield refineries, which normally demand a 4- to 5-year design, engineering, and construction period, plus very significant levels of capital investment.

The International Bauxite Association (IBA), created in 1974 by the leading bauxite producing countries of the time, was disbanded at yearend 1994. The decision to dissolve the 20-year old organization followed an extended period of uncertainty regarding the future of the group, caused primarily by the recent loss of several key member countries and increasing funding problems.

Australia.—In 1994, production levels rose in this, the world's largest bauxite and alumina producing country. Bauxite output was up by nearly 1% and alumina increased by 2%.

Australia's alumina exports to Russia in 1994 were projected to leap to 600,000 tons, up from the 25,000 tons reportedly shipped in 1993, following agreements established between Alcoa of Australia Ltd. and Comalco Ltd. and a group of Siberian aluminum smelters. Under the agreements, the two Australian alumina producers contracted to deliver smelter-grade alumina worth $147 million (A$200 million) to as many as six Siberian primary aluminum production facilities in 1994.[2]

In another Australian development, it was announced that ACAP-Australia Pty. Ltd., a joint venture between Alcoa's Industrial Chemicals Division and Alcoa of Australia, planned to construct a 270,000-ton-per-year aluminum trihydrate (ATH) facility at Alcoa's Kwinana alumina plant in Western Australia. It was planned that this new $29.1 million (A$42.9 million) ATH production expansion would be brought on-stream in two stages, the first to be completed by the fourth-quarter of 1994 and the second-quarter in 1995.[3]

Additionally, Alcoa of Australia indicated that it was considering expanding alumina production at its Wagerup alumina plant in Western Australia. The company has commenced an Environmental Review Process which, if approved, would allow it to expand Wagerup's annual production capacity to 3.3 million tons per year, approximately twice its current capacity. It was suggested that the final approval from the Western Australian state government on the environmental aspects of this possible expansion could take up to 2 years.[4]

Brazil.—It was announced that Mineraçao Rio do Norte (MRN), Brazil's largest bauxite producer, would invest $230 million to increase output from 8 million tons per year to 12 million tons per year at its Trombetas bauxite mining operation in the Amazon Basin. The purpose of this investment was to insure that sufficient metallurgical-grade bauxite would be available when the new 1.1-million-ton-per-year greenfield Alunorte alumina plant being constructed near Belem, Pará, becomes operational in 1995.[5]

China.—The Shanxi aluminum smelter complex reportedly completed a successful trial run of its new $45 million alumina plant expansion, scheduled to come on-stream by yearend 1994. This second-stage expansion will bring the Shanxi facility's annual alumina production capacity up to 1.2 million tons per year and make Shanxi the largest alumina producer in China.[6]

Ghana.—Reports indicated that the Ghana Bauxite Co. (GBC) was considering a plan to build an aluminum sulfate plant to supply western Africa's water treatment industries. The GBC joint venture is owned by Alcan Chemicals Europe (45%) and the government of Ghana (55%).[7]

Hungary.—It was reported that the Hungarian aluminum producer, Hungalu, permanently closed its 330,000-ton-per-year Almafuzito alumina plant in early November. This plant closure also resulted in the cessation of bauxite mining operations at Csabpuszta, Nyirad District, in the latter part of 1994.[8]

India.—Alcoa and Larsen & Toubro Ltd., a Bombay-based engineering company, agreed to study the feasibility of forming a joint venture to construct a bauxite mining and alumina refining complex in the state of Orissa in India. The proposed greenfield project, with an estimated cost of about $700 million, would produce 1 million tons of alumina per year for export.[9]

In addition, India's private-sector Hindustan Aluminium Corp. Ltd. (Hindalco) has entered into a technology assistance agreement with Reynolds Metals Co. to increase the alumina production capacity of its alumina plant at Renukoot, Uttar Pradesh, from 350,000 tons per year to 450,000 tons per year.[10]

In a similar development, Indian Aluminium Co. (Indal), Tata Industries Ltd., India's largest business group, and Norsk Hydro of Norway agreed to build and jointly operate a 1-million-ton-per-year alumina plant in India's eastern state of Orissa. Construction of the alumina plant was expected to start in 1995 and, once in operation, all production would be exported to international markets. A bauxite mine reportedly had been leased by Indal and was being developed by Utkal Alumina International Private Ltd., the joint-venture company formed to manage the alumina project.[11]

Despite this flurry of future expansion plans, late in 1994, National Aluminium Co., Ltd. (Nalco) announced plans to reduce its alumina production by 10% due to low demand. In the 1993-94 business year, Nalco reportedly produced 753,000 tons of alumina, 372,000 tons of which were shipped to export markets.[12]

Jamaica.—Due to depressed international prices for aluminum metal, the Kaiser Jamaica Bauxite Co. announced plans to reduce its bauxite production by 500,000 tons for the year, an approximate 15% drop in annual output.[13]

In a further development, the Jamaica Bauxite Institute (JBI) continued work on a feasibility study to establish a 1-million-ton-per- year greenfield alumina plant in the Parish of Trelawny on the north coast of Jamaica. JBI conducted field work and exploration drilling to confirm bauxite reserves for the intended plant. It was estimated that 2.5 million tons of metallurgical-gradebauxite would be required to feed this facility.[14]

Kazakhstan.—Bauxite occurrences were included among the designated properties offered in the Republic of Kazakhstan's first official international minerals and metals tender that occurred at mid- year. A total of 40 mineral and metal properties were included in this solicitation, which sought applications from the international exploration and mining community to evaluate and participate in the development of Kazakhstan's mineral resources.

Russian Federation.—A significant development in the former Soviet Union (FSU) involved the announcement that the first stage of a new bulk unloading terminal for the handling of alumina had been successfully installed and commissioned in early 1994 at Vanino, a seaport in Russia's Far East. The opening of this east coast transshipment facility marked a major attempt to clear one of the principal raw materials supply bottlenecks that has hampered the large hydroelectric powered Russian aluminum smelters in the remote regions of Siberia. This new bulk alumina handling terminal was jointly owned by Trans-World Metals, a trading group based in the United Kingdom, and the Vanino Port Authority, a new Russian joint stock company. A second stage expansion was also reportedly scheduled to commence operation within 3 months of the terminal's initial startup and should lift the bulk alumina handling capacity at Vanino to 50,000 tons per month.[15]

In a related matter, news reports indicated that construction was scheduled to begin in mid-1994 on a new 1-million-ton-per-year alumina transshipment facility at the seaport of Murmansk, in northwestern Russia. This proposed new bulk handling terminal reportedly was designed to include two pneumatic unloaders, a conveyor system, two 16,000-ton storage silos, and a rail car loader.[16]

Saudi Arabia.—In a continuing attempt to develop a locally derived source of feed for the Persian Gulf region's aluminum industry, Saudi Arabia solicited bids for a feasibility study covering the construction of an open pit mining operation at its Az Zabirah bauxite deposit. Estimates currently place known minable reserves of the Az Zabirah deposit at 102 million tons.[17]

South Africa.—During the year, Gencor Ltd. of South Africa finalized its purchase of the minerals and metals operations owned by Billiton, a subsidiary of the Royal Dutch/Shell Group. The final purchase price reportedly agreed upon for the assets was $1.14 billion after a $15 million cash investment in Billiton's bauxite and alumina operations in Suriname. This wide ranging agreement encompassed exploration, mining, processing, and marketing assets in 15 different countries comprising alumina, aluminum, bauxite, copper, gold, nickel, and zinc.[18] *(See tables 13 and 14.)*

Outlook

Presently identified world bauxite reserves are sufficient to meet cumulative world demand well into the next century. Considering the high probability of discovering additional bauxite deposits, plus the added possibility of employing lower grade bauxite occurrences and various alternative sources of alumina, world resources of aluminum remain adequate to satisfy demand for the foreseeable future.

The continued and extended economic restructuring of Eastern Europe and the newly independent republics of the FSU provide significantly increased market opportunities for the established bauxite- and alumina-producing countries of the world. The quality and quantity of bauxite resources within the former Eastern bloc nations are incapable of sustaining an economically viable market-based aluminum industry. To become truly competitive in the "new global economy," major amounts of imported bauxite and alumina feedstocks will be required to supply the primary aluminum production facilities of the FSU. The most crucial element in the development of this trade pattern will be the implementation of adequate and reliable payment or tolling mechanisms for the continued timely transfer of these vital raw materials to the aluminum industry of the FSU.

In 1994, metallurgical-grade bauxite and alumina markets were markedly weakened by a worldwide reduction in primary aluminum metal production. Although, at the close of the year, the outlook for the producers of these aluminum industry feedstocks appeared to substantially improve, with the prospect of the possible restarting of several previously idled aluminum smelters and the expected commissioning of additional greenfield primary aluminum metal production capacity in 1995. Currently, both the short- and long-term growth prospects for bauxite and alumina are believed to be rather robust and a bright future is forecast for these aluminum industry raw materials. This projection is based on the belief that the current worldwide economic expansion will continue well into the latter portion of the decade and create an increased demand for aluminum metal in the late 1990's.

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[3] Industrial Minerals. Alcoa Sets Up ATH Plant. No. 318, Mar. 1994, p. 8.

[4] Metal Bulletin. Alcoa to Expand Wagerup Alumina Plant. No. 7904, Aug. 11, 1994, p. 5.

[5] American Metal Market. MRN Planning Bauxite Expansion. V. 102, No. 167, Aug. 30, 1994, p. 7.

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[16] Metal Bulletin Monthly. Metals Exports Fund Russian Alumina Handling Project. V. 280, Apr. 1994, p. 24.

[17] Platt's Metals Week. Saudis Seek Investment for Bauxite Production. V. 65, No. 19, May 9, 1994, p. 10.

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TABLE 1
SALIENT BAUXITE STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Production: Crude ore (dry equivalent)	W	W	W	W	W
Value	W	W	W	W	W
Exports (as shipped)	74	51	63	90	129
Imports for consumption 2/	12,100	11,900	10,900	11,600	10,700
Consumption (dry equivalent)	12,000	12,200	11,900	11,900	11,700
World: Production	113,000 r/	111,000 r/	105,000 r/	108,000 r/	107,000 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Excludes calcined bauxite. Includes bauxite imported to the U.S. Virgin Islands.

TABLE 2
PRODUCTION AND SHIPMENTS OF ALUMINA IN THE UNITED STATES 1/

(Thousand metric tons)

Year	Calcined alumina	Other alumina 2/	Total	
			As produced or shipped 3/	Calcined equivalent
Production: e/				
1993	4,840	655	5,490	5,290
1994	4,360	730	5,090	4,860
Shipments: e/				
1993	4,780	660	5,440	5,230
1994	4,380	700	5,080	4,850

e/ Estimated.

1/ Data rounded by the U. S. Bureau of Mines to three significant digits.

2/ Trihydrate, activated, tabular, and other aluminas. Excludes calcium and sodium aluminates.

3/ Includes only the end product if one type of alumina was produced and used to make another type of alumina.

TABLE 3
CAPACITIES OF DOMESTIC ALUMINA PLANTS, 1/ 2/ DECEMBER 31

(Thousand metric tons per year)

Company and plant	1993	1994
Aluminum Co. of America: Point Comfort, TX	1,740	1,740
Kaiser Aluminum & Chemical Corp.: Gramercy, LA	1,000	1,000
Ormet Corp.: Burnside, LA	600	600
Reynolds Metals Co.: Corpus Christi, TX	1,700	1,600
Virgin Islands Alumina: St. Croix, VI	635	635
Total	5,670	5,570

1/ Capacity may vary depending on the bauxite used.

2/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 4
U.S. CONSUMPTION OF BAUXITE, BY INDUSTRY 1/

(Thousand metric tons, dry equivalent)

Industry	1993	1994
Alumina	11,000	10,900
Abrasive 2/	203	197
Chemical	225	192
Refractory	429	384
Other	58	52
Total	11,900	11,700

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes consumption by Canadian abrasive industry.

TABLE 5
PRODUCTION AND SHIPMENTS OF SELECTED ALUMINUM SALTS IN THE UNITED STATES IN 1993 1/

Item	Number of producing plants	Production (thousand metric tons)	Total shipments, including interplant transfers: Quantity (thousand metric tons)	Total shipments, including interplant transfers: Value (thousands)
Aluminum sulfate:				
Commercial and municipal (17% Al2O3)	69	952	934	$102,000
Iron-free (17% Al2O3)	22	157	158	21,000
Aluminum chloride:				
Liquid and crystal	6	19	5	W
Anhydrous (100% AlCl3)	4	18	18	11,700
Aluminum fluoride, technical	3	W	W	W
Aluminum hydroxide, trihydrate [100% Al(OH)3]	10	829	829	171,000
Aluminates	17	116	114	24,900
Other aluminum compounds 2/	XX	XX	XX	190,000

W Withheld to avoid disclosing company proprietary data. XX Not applicable.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits.

2/ Includes light aluminum hydroxide, cryolite, etc.

Source: Data are based on Bureau of the Census 1993 Current Industrial Reports, Series MA-28A, "Inorganic Chemicals."

TABLE 6
STOCKS OF BAUXITE IN THE UNITED STATES, 1/ 2/ DECEMBER 31

(Thousand metric tons, dry equivalent)

Sector	1993	1994
Producers, processors, and consumers	1,590 r/	1,580
Government	16,900	17,600
Total	18,500 r/	19,200

r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Domestic and foreign bauxite; crude, dried, calcined, activated, all grades.

TABLE 7
STOCKS OF ALUMINA IN THE UNITED STATES, 1/ 2/ DECEMBER 31

(Thousand metric tons, calcined equivalent)

Sector	1993	1994
Producers	521 r/	478
Primary aluminum plants	1,210	1,100
Total	1,730 r/	1,570

r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes consumers stocks other than those at primary aluminum plants.

TABLE 8
AVERAGE VALUE OF U.S. IMPORTS OF CRUDE AND DRIED BAUXITE 1/

(Per metric ton)

Country	1993		1994	
	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)
Australia	$12.41	$20.81	$10.00	$20.25
Brazil	28.67	36.18	27.68	35.62
Guinea	25.43	32.68	23.53	30.83
Guyana	32.06	42.00	27.29	38.35
Jamaica	28.95	34.46	25.08	30.11
Weighted average	27.84	34.84	25.10	32.13

1/ Computed from quantity and value data reported to U.S. Customs Service and compiled by the Bureau of the Census, U. S. Department of Commerce. Not adjusted for moisture content of bauxite or differences in methods used by importers to determine value of individual shipments.

TABLE 9
U.S. EXPORTS OF ALUMINA, 1/ 2/ BY COUNTRY

(Thousand metric tons, calcined equivalent, and thousand dollars)

Country	1993		1994	
	Quantity	Value	Quantity	Value
Brazil	247	39,200	234	47,500
Canada	814	170,000	726	139,000
Finland	25	4,050	(3/)	447
Mexico	38	21,300	33	18,500
Netherlands	20	5,500	14	9,150
Norway	20	3,370	--	--
Sweden	14	2,350	(3/)	133
Other	62 r/	60,300 r/	35	56,900
Total	1,240	306,000	1,040	271,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes exports of aluminum hydroxide (calcined equivalent) as follows: 1993 -- 34,400 tons and 1994 -- 44,200 tons.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF BAUXITE, CRUDE AND DRIED, 1/ 2/ BY COUNTRY

(Thousand metric tons)

Country	1993	1994
Australia	148	54
Brazil	1,860	1,630
China	120	61
Guinea	3,780	3,740
Guyana	1,290	1,150
Indonesia	387	390
Jamaica 3/	3,920	3,650
Malaysia	11	--
Other	104	67
Total	11,600	10,700

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes bauxite imported to the U.S. Virgin Islands from foreign countries.

3/ Dry equivalent of shipments to the United States.

NOTE.--Total U.S. imports of crude and dried bauxite (including the U.S. Virgin Islands) as reported by the Bureau of the Census were as follows: 1993 -- 11,600,000 tons and 1994 -- 9,870,000 tons.

Source: Bureau of the Census and the Jamaica Bauxite Institute.

TABLE 11
U. S. IMPORTS FOR CONSUMPTION OF CALCINED BAUXITE, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993				1994			
	Refractory grade		Other grade		Refractory grade		Other grade	
	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/
Australia	--	--	12	985	--	--	7	553
Brazil	16	1,120	--	--	2	181	24	1,890
China	66	3,600	86	4,280	153	6,540	137	6,820
Guyana	53	6,750	--	--	25	3,110	--	--
Other	--	--	4	264	--	--	--	--
Total	135	11,500	102	5,530	181	9,830	168	9,260

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Value at foreign port of shipment as reported to U. S. Customs Service.

Source: Bureau of the Census; data adjusted by the U. S. Bureau of Mines.

TABLE 12
U. S. IMPORTS FOR CONSUMPTION OF ALUMINA, BY COUNTRY 1/

(Thousand metric tons, calcined equivalent, and thousand dollars)

Country	1993		1994	
	Quantity	Value 2/	Quantity	Value 2/
Australia	2,720	443,000	2,080	328,000
Brazil	33	9,740	11	6,020
Canada	84	46,400	84	50,600
France	10	17,500	11	14,600
Germany	22	37,800	34	54,600
Guinea	28	4,750	--	--
India	116	18,900	102	17,600
Israel	(3/)	6	--	--
Italy	(3/)	596	(3/)	407
Jamaica	379	62,800	320	50,000
Japan	8	16,100	8	16,600
Suriname	313	49,000	187	26,000
Venezeula	85	17,200	126	27,100
Other	141	30,300	160	31,100
Total	3,940	754,000	3,120	623,000

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Value at foreign port of shipment as reported to U. S. Customs Service.

3/ Less than 1/2 unit.

Source: Bureau of the Census; data adjusted by the U. S. Bureau of Mines.

TABLE 13
BAUXITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Albania e/	26	20	4	2	2
Australia	41,400	40,500	39,700	41,300 r/	41,700 3/
Bosnia and Herzegovina	XX	XX	200	100 e/	75
Brazil	9,680	10,400	9,370	9,410 r/	8,120
China e/	2,400	2,600	2,700	3,500 r/	3,700
Croatia	XX	XX	7	2	10
Dominican Republic 4/	85	7	--	--	--
France	490	9	--	--	--
Ghana	381	353 e/	338	424	426 3/
Greece	2,500	2,130	2,040	1,700 e/	1,600
Guinea 4/	15,800	15,500	13,800 e/	14,100 e/	14,400
Guyana 4/	1,420	2,200	2,380	2,130 e/	2,100
Hungary	2,560	2,040	1,720	1,560 r/	900
India	4,850	4,740	4,900	5,220	5,400
Indonesia	1,210	1,410	804	1,320	1,300
Iran e/	100	100	100	100	100
Italy	(5/)	9 e/	98	90 r/	90
Jamaica 4/ 6/	10,900	11,600	11,300 e/	11,400 r/	11,700 3/
Kazakhstan	XX	XX	3,040 r/	3,000 r/	2,430 3/
Malaysia	398	376	331 e/	69	162 3/
Mozambique	7	8	8	6 e/	10 3/
Pakistan	3	4	3	5	5
Romania	243	200	175	186 r/	184
Russia	XX	XX	4,580 r/	4,260 r/	3,000
Serbia and Montenegro	XX	XX	792	102 r/	--
Sierra Leone	1,430	1,290	1,250 e/	1,170	735 3/
Spain	1	1 e/	--	--	--
Suriname	3,280	3,200	3,250 e/	3,400 e/	3,440
Turkey 7/	773	489	613 r/	538 r/	500
U.S.S.R. 8/	9,250 r/	7,870 r/	XX	XX	XX
United States	W	W	W	W	W
Venezuela	771	1,990	1,050 e/	2,910 e/	4,790 3/
Yugoslavia 9/	2,950	1,910	XX	XX	XX
Total	113,000 r/	111,000 r/	105,000 r/	108,000 r/	107,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 26, 1995.

3/ Reported figure.

4/ Dry bauxite equivalent of crude ore.

5/ Less than 1/2 unit.

6/ Bauxite processed for conversion to alumina in Jamaica plus kiln-dried ore prepared for export.

7/ Public-sector production only.

8/ Dissolved in Dec. 1991. In addition to the bauxite reported in the body of the table, Russia produces nepheline syenite concentrates and Azerbaijan produces alunite ore as sources of aluminum. Estimated nepheline syenite concentrate, produced in Russia was as follows, in thousand metric tons: 1990--1,650; 1991--1,500; 1992--1,500; 1993--1,390 (reported) and 1994--1,300. Estimated alunite ore produced in Azerbaijan was as follows, in thousand metric tons: 1990--550; 1991--500; 1992--300; 1993--200; and 1994--150. Nepheline syenite concentrate grades 25% to 30% alumina, and alunite ore grades 16% to 18% alumina; these commodities may be converted to their bauxite equivalent by using factors of 1 ton of nepheline syenite concentrate equals 0.55 ton of bauxite and 1 ton of alunite equals 0.34 ton of bauxite.

9/ Dissolved in Apr. 1992.

TABLE 14
ALUMINA: WORLD PRODUCTION, 1/ BY COUNTRY 2/ 3/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Australia	11,200	11,700	11,800	12,600	12,900 4/
Azerbaijan	XX	XX	300	200 e/	150
Bosnia and Herzegovina	XX	XX	100 e/	50 e/	50
Brazil	1,660	1,740	1,830	1,830	1,870
Canada	1,090	1,130	1,100	1,180 r/	1,170
China e/	1,460	1,520	1,580	1,820 r/	1,900
Czechoslovakia e/ 5/ 6/	175	187 r/	143 r/	XX	XX
France	606	538	508	476 r/	438 4/
Germany:					
Eastern states	50 r/	XX	XX	XX	XX
Western states	922	XX	XX	XX	XX
Total	972 r/	863	857	840 r/	850
Greece	587	625	612	510 e/	475
Guinea	631	610	561	600 e/	600
Hungary	826	635	548	450 e/	175
India e/	1,600 4/	1,700	1,700	1,800	2,000
Ireland	885 e/	981	973 r/	1,100 r/ e/	1,000
Italy 7/	752	805	762	840 r/ e/	825
Jamaica	2,870	3,020	2,920	2,990	3,220 4/
Japan 8/	481	438	316	327	300
Kazakhstan e/	XX	XX	1,100	1,000	700
Romania	440	413	280	293 e/	302 4/
Russia e/	XX	XX	3,100	3,500	2,600
Serbia and Montenegro e/	XX	XX	197	12 r/	15
Slovakia e/ 6/	XX	XX	XX	140	140
Slovenia e/	XX	XX	45	40	40
Spain 7/	1,000	1,000 e/	959	1,060 r/ e/	1,000
Suriname	1,530	1,510	1,580	1,500 e/	1,500
Turkey	177	159	156	142 r/	145
Ukraine e/	XX	XX	1,100 r/	1,010 r/	1,070
U.S.S.R. e/ 9/	5,900	5,280 3/	XX	XX	XX
United Kingdom e/	115	110	120 r/	105 r/	105
United States	5,230	5,230	5,190	5,290	4,860 4/
Venezuela	1,290	1,300	1,310	1,500 e/	1,650
Yugoslavia 10/	1,090	900 e/	XX	XX	XX
Total	42,600 r/	42,400	41,700 r/	43,200 r/	42,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Figures represent calcined alumina or the total of calcined alumina plus the calcined equivalent of hydrate when available; exceptions, if known, are noted.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Table includes data available through June 26, 1995.

4/ Reported figure.

5/ Dissolved Dec. 31, 1992.

6/ All production in Czechoslovakia from 1990-92 came from Slovakia.

7/ Hydrate.

8/ Data presented are for alumina used principally for specialty applications. Gross weight of aluminum hydrate for all uses was as follows, in thousand metric tons: 1990--890; 1991--864; 1992--714; 1993--704; 1994--not available.

9/ Dissolved in Dec. 1991.

10/ Dissolved in Apr. 1992.

BERYLLIUM

By Deborah A. Kramer

Beryllium is a light weight material with a stiffness six times greater than that of steel, a high heat-absorbing capability, and dimensional stability over a wide range of temperatures. These properties allow it to be used as metal, alloy, or oxide in a wide range of consumer and defense applications, including automotive electronics, computers, and telecommunications systems.

The United States is one of few countries with an integrated beryllium industry. Bertrandite, mined and processed in Utah, is the primary source of ore for the end products—beryllium alloys, beryllium metal, and beryllium oxide—that are produced in Ohio and Pennsylvania. Imported beryl ore, mainly from Brazil, has supplemented domestic ore supply in the past, but insignificant quantities of beryl have been imported in recent years.

Reported U.S. consumption of beryllium ore declined in 1994, but the production of nearly all beryllium products, with the exception of metallic beryllium, increased. Computers and automotive electronics were the two principal uses of beryllium-containing materials. Consumption of beryllium is expected to remain stable or increase slowly over the next few years as new uses for beryllium alloys are developed. *(See table 1.)*

Legislation and Government Programs

Deliveries of beryllium metal to the National Defense Stockpile (NDS) were completed in the second quarter of 1994 under the terms of a contract initiated in 1990. The total quantity of metal delivered to the NDS under this contract was 73 metric tons, recovered from 2,940 tons of beryl in the NDS. *(See table 2.)*

In the fiscal year 1995 Annual Materials Plan, the Defense National Stockpile Center (DNSC) recommended that beryl sales for the fiscal year be limited to 1,800 tons. The quantities in the plan are the maximum quantities that can be sold.

Beginning in October, DNSC offered beryl ore for sale. On the third Tuesday of each subsequent month, DNSC solicited bids for 1,800 tons of beryl. There were no bids to purchase this material during 1994.

Production

Domestic production of beryllium ore declined in 1994. Conversely, production of beryllium-containing products—beryllium-aluminum alloys, beryllium-copper master alloy, beryllium-nickel alloys, and beryllium oxide—increased, with the exception of beryllium metal. Metallic beryllium production declined primarily as a result of the completion of the NDS contract.

The United States is the only country that can process beryllium ore and concentrates into beryllium products and supplies most of the rest of the world with these products. Brush Wellman Inc. mines bertrandite and converts this ore, along with beryl, to beryllium hydroxide at its facility in Delta, UT. Beryllium hydroxide is shipped to the company's plant in Elmore, OH, where it is converted into beryllium alloys, oxide, and metal.

One other company in the United States has the capability to produce beryllium alloys. NGK Metals Corp., a subsidiary of NGK Insulators of Japan, produces beryllium alloys at a plant near Reading, PA. Because NGK Metals does not have facilities to process the raw materials, the company purchases beryllium oxide from Brush Wellman.

Beryllium data are collected from two voluntary surveys of U.S. operations. In 1994, there were five responses to the "Beryllium Mineral Concentrate and Beryllium Ore" survey, representing 63% of the total canvassed. These respondents produced 100% of total domestic mine shipments, shown in tables 1 and 7. A small number of unidentified producers may have shipped insignificant quantities of byproduct beryl, which have not been included.

Beryllium dust and fumes have been recognized as the cause of beryllosis, a serious chronic lung disease. In the 1940's, the disease was diagnosed among industry employees and their relatives, who had handled dusty workclothes prior to the establishment of suitable hygienic procedures. Cases also were reported among residents of communities surrounding beryllium-processing plants. Although uncertainties related to the cause of the disease still exist, the problem appears to be controlled when established preventative measures are exercised. In beryllium-processing plants, harmful effects are prevented by maintaining clean workplaces; requiring the use of safety equipment such as personal respirators; collection of dust, fumes, and mists at the source of deposition in dust collectors; medical programs; and other procedures to provide safe working conditions. Control of potential health hazards adds significantly to the final cost of beryllium products.

Consumption

Reported beryllium ore consumption declined in 1994 even though Brush Wellman reported increases in sales in nearly all the company's product lines. Sales increases in beryllium alloys were attributed to a high level of demand for these materials in electronic applications and to development of new applications in automotive electronics, appliances, plastic molding, and telecommunications markets. Brush Wellman estimated that the demand pattern for the company's products, based on sales, was aerospace and defense, 14%; appliance and consumer applications, 11%; automotive electronics, 18%; computers, 36%; telecommunications, 12%; and other uses, 9%.

Beryllium-Copper Alloys.—Beryllium-copper alloys are used in a wide variety of applications and average about 75% of annual U.S. consumption on a beryllium metal equivalent basis. These alloys, most of which contain approximately 2% beryllium, are used because of their high electrical and thermal conductivity, high strength and hardness, good corrosion and fatigue resistance, and nonmagnetic properties. Beryllium-copper strip is manufactured into springs, connectors, and switches for use in applications in automobiles, aerospace, radar and telecommunications, factory automation, computers, home appliances, and instrumentation and control systems. The principal use of large-diameter beryllium-copper tubing is in oil and gas drilling equipment and in bushings and bearings in aircraft landing gear and heavy machinery. Connectors in fiber-optic telecommunications systems are the main application for beryllium-copper rod. Small, pluggable sockets for joining integrated circuits to printed circuit boards are the main application for beryllium-copper wire. Beryllium-copper bar and plate are used in resistance-welding parts, components for machinery and materials-handling systems, and for molds to make metal, glass, and plastic components.

Beryllium also is used in small quantities in nickel- and aluminum-base alloys. Miniature electronic connector components that operate at high temperatures are the main use for beryllium-nickel alloys, and these alloys are used in automotive passive restraint systems (air bags). Beryllium-aluminum alloys are used as castings in the aerospace industry. Addition of small quantities of beryllium to magnesium alloys inhibits oxidation.

Beryllium Metal.—Beryllium metal, which averages about 10% of annual U.S. demand, is used principally in aerospace and defense applications. Its high stiffness, light weight, and dimensional stability over a wide temperature range make it useful in satellite and space vehicle structures, inertial guidance systems, military aircraft brakes, and space optical system components. Because beryllium is transparent to X-rays, it is used in X-ray windows. In nuclear reactors, beryllium also serves as a canning material, as a neutron moderator, in control rods, and as a reflector. In the past, the metal had been used as a triggering device in nuclear warheads. Other applications for metallic beryllium include high-speed computer components, audio components, and mirrors. In the U.S. space shuttles, several structural parts and brake components use beryllium.

Beryllium Oxide.—Beryllium oxide (beryllia) is an excellent heat conductor, with high hardness and strength. This material also acts as an electrical insulator in some applications. Beryllium oxide, averaging about 15% of domestic demand, serves mainly as a substrate for high-density electronic circuits for high-speed computers, automotive ignition systems, lasers, and radar electronic countermeasure systems. Because it is transparent to microwaves, microwave communications systems and microwave ovens may use beryllium oxide.

Because of its high cost compared to those of other materials, beryllium is used in applications in which its properties are crucial. Steel, titanium, or graphite composites substitute for beryllium metal in some applications, and phosphor bronze substitutes for beryllium-copper alloys, but these substitutions result in substantial loss in performance. In some cases, aluminum nitride may be substituted for beryllium oxide.

Prices

Yearend prices for beryllium products are shown in table 3. Prices for beryllium products at yearend 1994 were unchanged from those at yearend 1993. *(See table 3.)*

Foreign Trade

The Bureau of the Census does not separately identify all imports and exports of beryllium-copper alloys. The Journal of Commerce Port Import/Export Reporting Service (PIERS) provides some data on materials that are transported by ship. According to PIERS, 81 tons (gross weight) of beryllium-copper alloys in strip, bar, rod, and plate forms were exported in 1994. Principal destinations were Japan (48%) and Brazil (37%). In addition, 300 tons of beryllium-copper scrap was exported to Japan, and 8 tons of beryllium-aluminum alloys wasexported to Belgium (67%) and Brazil (33%). Imports of beryllium-copper alloys totaled 1,600 tons in the form of strip and billet, all from Japan. *(See tables 4 and 5.)*

World Review

In Japan, demand for beryllium-copper alloys in 1994 rebounded to about 1,300 tons from an estimated 1,250 tons in 1993. Increased production of personal computers and information and telecommunications instruments were responsible for part of the increase in demand for beryllium-copper rolled materials. In addition, exports of automotive components to the United States increased, contributing to the increase in demand for beryllium-copper rolled products. One of the Japanese beryllium-copper producers, Nippon Gaishi, introduced a lower cost beryllium alloy that contains less than 1% beryllium. The higher cost beryllium-copper alloy was used traditionally in industrial appliances, but because of its cost, it was not used in domestic appliances. With the introduction of the low-cost alloy, beryllium-copper could be used in domestic appliances, yielding smaller appliances with higher performance and special features that could not be achieved with phosphor bronze connectors and switches.[1] *(See tables 6 and 7.)*

Outlook

Consumption of beryllium materials in the United States is expected to grow slowly or remain at essentially the same level for the next few years. Metallic beryllium production likely will decline as the commitments to the NDS were completed in 1994, and defense applications have declined over the past several years. Companies that produce beryllium alloys are developing new applications for these materials, particularly in automotive electronics, so demand for the alloys will probably increase. If the increase in alloy demand offsets the decline in metal demand, overall beryllium demand will increase.

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[1] Roskill's Letter From Japan. No. 226, Feb. 1995, pp. 7-9.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Beryllium. Ch. in Mineral Commodity Summaries, annual.

Other Sources

American Metal Market (daily newspaper).

Brush Wellman Inc., Annual Report.

Metals Week.

Roskill Information Services Ltd. Beryllium 1989, 5th ed.

TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium metal equivalent unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Beryllium-containing ores:					
Mine shipments	182	174	193	198	173
Imports for consumption, beryl1/	14	12	2	2	--
Consumption, reported	232	196	196	196	174
Price, approximate, per short ton unit BeO, imported cobbed beryl at port of exportation	$101	$113	NA	NA	NA
Yearend stocks	119	112	111	114	113
World: Production1/	284	263	278	270 r/	245 e/

e/Estimated. r/Revised. NA Not available.

1/Based on a beryllium metal equivalent of 4% in beryl.

TABLE 2
STOCKPILE STATUS, DECEMBER 31, 1994

(Metric tons, beryllium content)

Material	Goal	Uncommitted inventory	Authorized for disposal
Beryllium-copper master alloy	287	268	--
Beryllium metal	363	363	--
Beryllium ore	653	526	526

TABLE 3
YEAREND BERYLLIUM PRICES

(Dollars per pound unless otherwise specified)

Material		Price
Beryl ore	per short ton unit of contained BeO	$78- $85
Beryllium vacuum-cast ingot, 98.5% pure		308
Beryllium metal powder, in 1,000- to 4,999-pound lots and 98.5% pure		295
Beryllium-copper master alloy	per pound of contained Be	160
Beryllium-copper casting alloy		5.52- 6.30
Beryllium-copper in rod, bar, wire		10.24
Beryllium-copper in strip		9.25
Beryllium-aluminum alloy, in 100,000-pound lots		260

Sources: American Metal Market, Brush Wellman Inc., and Platt's Metals Week.

TABLE 4
U.S. EXPORTS OF BERYLLIUM ALLOYS, WROUGHT OR UNWROUGHT, AND WASTE AND SCRAP,1/ BY COUNTRY 2/

Country	1993 Quantity (kilograms)	1993 Value (thousands)	1994 Quantity (kilograms)	1994 Value (thousands)
Canada	5,240	$263	7,180	$240
France	92	93	911	1,050
Hungary	6,880	224	18	3
Japan	3,140	560	7,380	535
Netherlands	1,310	101	578	135
Taiwan	--	--	8,070	124
United Kingdom	1,910	112	3,280	393
Other	1,150 r/	410 r/	1,060	223
Total	19,700	1,760	28,500	2,700

r/Revised.

1/Consisting of beryllium lumps, single crystals, powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.

2/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF BERYLLIUM METAL AND COMPOUNDS 1/

Material	1993 Quantity (kilograms)	1993 Value (thousands)	1994 Quantity (kilograms)	1994 Value (thousands)
Beryllium-copper master alloy	107,000	$1,220	182,000	$2,270
Beryllium oxide and hydroxide	2,430	38	225	3
Beryllium, unwrought and waste and scrap	6,180	432	52,500	1,900

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 6
WORLD ANNUAL BERYL PRODUCTION CAPACITY,1/
DECEMBER 31, 1994

(Metric tons, contained beryllium)

	Capacity
North America: United States2/	360
Africa:	
Madagascar	5
Mozambique	3
Rwanda	3
South Africa, Republic of	3
Zimbabwe	5
Total	19
Asia: China	75
Europe:	
Kazakhstan	7
Portugal	3
Russia	70
Total	80
South America:	
Argentina	4
Brazil	65
Total	69
World total	603

1/Includes capacity at operating plants as well as at plants on standby basis.

2/Includes bertrandite ore.

TABLE 7
BERYL: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina	34	34	34 e/	-- r/ e/	--
Brazil e/	850	850	850	850	850
Kazakhstan e/	XX	XX	100	100	100
Madagascar e/ 4/	3 5/	3	3	3	3
Namibia	25	6	10 e/	15 r/	15
Nepal	1	-- r/	-- r/	-- r/	--
Portugal e/	4	4	4	4	4
Russia e/	XX	XX	1,100	800	800
South Africa, Republic of	1	(6/)	--	--	--
U.S.S.R. e/ 7/	1,600	1,300	XX	XX	XX
United States 8/ (mine shipments)	4,550	4,340	4,830	4,940	4,330 5/
Zambia	2	1	1	1	1
Zimbabwe (concentrate, gross weight)	28	29	23	32 r/	30
Total	7,100	6,570	6,950	6,740 r/	6,130

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through Apr. 6, 1995.

3/ In addition to the countries listed, China produced beryl and Bolivia may also have produced beryl, but available information is inadequate to formulate reliable estimates of production.

4/ Includes ornamental and industrial products.

5/ Reported figure.

6/ Less than 1/2 unit.

7/ Dissolved in Dec. 1991.

8/ Includes bertrandite ore, calculated as equivalent to beryl containing 11% BeO.

BISMUTH

By Robert D. Brown, Jr.

Domestic consumption of bismuth increased moderately in 1994. The domestic use pattern was similar to that for 1993, but with increases in all three major categories: chemicals, fusible alloys, and metallurgical additives. Chemical uses continued to account for more than 50% of consumption.

There was increasing interest in using bismuth as a nontoxic substitute for lead in several applications. Applications such as bismuth oxide in the fire assaying of precious metals, bismuth ceramic glazes, and bismuth shotgun pellets have been implemented. Phase I of the American Foundrymen's Society/U.S. Department of Commerce research has been completed. This work indicates that combinations of bismuth and selenium have good potential for replacing lead in certain brasses for many plumbing component applications.

Domestic consumption and production data are collected through a voluntary survey. Of the 50 firms that received the consumption form in 1994, 70% responded. The respondents accounted for 84% of the bismuth consumption figure for the United States. The amount used by the nonrespondents was estimated on the basis of reports from prior years or from other sources.

Legislation and Government Programs

The Defense Logistics Agency (DLA), which maintains the National Defense Stockpile (NDS), sold 144,513 kilograms of bismuth from the Stockpile on September 14, 1994. This represented the total amount allocated for disposal in fiscal year 1994, which ended September 30, 1994. The DLA was authorized to dispose of another 136,000 kilograms of bismuth in fiscal year 1995. At the first offering on October 19, 1994, all bids were rejected by DLA as being too low. The Stockpile inventory on December 31, 1994, was 504,724 kilograms.

The U.S. Fish and Wildlife Service approved the use of 97% bismuth-3% tin shot for waterfowl hunting for the 1994-95 hunting season. The "conditional approval," was granted on the basis of initial testing which found that the shot was not toxic when ingested by waterfowl. The bismuth-tin shot is the first alternative to steel shot, which replaced lead for waterfowl hunting several years ago. The approval may be extended, based on longer term toxicity tests.[1]

Production

ASARCO Incorporated was the only domestic producer of primary bismuth. Production data are not published to avoid disclosing company proprietary information. Several firms recover bismuth from fusible alloy scrap. Secondary production data were not available.

Consumption

Domestic consumption increased moderately over that of 1993. The demand pattern remained similar to the one in 1993, with chemical uses accounting for over 50% of consumption.

The best known chemical use is that of bismuth subsalicylate, the active ingredient in over-the-counter stomach remedies. Other bismuth pharmaceuticals were used to treat burns, stomach ulcers, intestinal disorders, and for veterinary applications. Other bismuth chemical and compound uses included widely varying applications, such as pearlescent pigments in cosmetics and paints, fire assaying, ceramic glazes, varistors, and superconductors.

Bismuth metal use is categorized by fusible alloys, metallurgical additives, and other uses. Fusible (low melting point) alloys are combinations of bismuth and other metals such as cadmium, gallium, indium, lead, and tin. Applications include holding parts or lenses for machining or grinding, solders, fire sprinkler triggering mechanisms, and fuel tank safety plugs.

Bismuth is added to aluminum, copper, and steel to improve machinability. It is also added to malleable iron to prevent the formation of graphite flakes.

The discovery of an inappropriate accounting procedure resulted in revisions to U.S. Bureau of Mines figures for bismuth consumption for recent years. The error caused domestic bismuth consumption to be overreported by about 12% for the period covered in this survey, 1990-94. The revised figures are shown in table 1.

Prices

The domestic dealer price averaged $3.25 per pound for the year. The price was about $2.50 per pound during the first and second quarters, showing very little change since 1992. The price was increased rapidly to $4.10 per pound in July 1994 in response to concerns over possible shortages, particularly due to decreased shipments from China. It was held steady until late December when it was lowered to $4.00 per pound.

Foreign Trade

Imports for consumption of bismuth increased 25% by weight and 54% by value compared with those of 1993. Mexico and Belgium remained the largest suppliers to the United States. Imports from third ranked Canada increased dramatically, while those from China decreased significantly, dropping it from the third largest supplier in 1993 to sixth in 1994. Peru and the United Kingdom rounded out the top five suppliers in 1994.

Exports more than doubled by weight and increased by 34% in value in 1994 compared with those of 1993.

World Review

Usually bismuth is a byproduct of lead production. The Tasna Mine in Bolivia is the world's only significant primary source of bismuth. This mine has been closed since 1985, but the owners have obtained promising results from studies of the feasibility of reopening. Ore reserves of 700,000 metric tons, grading 1.7% bismuth, 0.6% copper, 0.3% tin, and 1.5 grams per ton of gold have been reported. The mine could be reopened late in 1995.

Current Research and Technology

A study and the first phase of experimental measurements have been completed to determine the feasibility of replacing lead with a bismuth/selenium combination in red brass (copper, tin, zinc, lead) in order to reduce possible toxicity from plumbing components. This work was organized, administered, and conducted by the American Foundrymen's Society, based in Des Plaines, Illinois, and the foundry industry and was supported by a grant from the Department of Commerce as well as contributions by the companies.

The study indicated an adequate supply of bismuth if it were used at a level of not more than 2% in the red brasses and also that the supply would increase significantly if the price did.

In the experimental phase, environmental characteristics as well as the foundry behavior, mechanical properties, and machinability characteristics were measured. The new alloys had slightly higher melting temperatures. Dross rates were somewhat higher, and the ductility of the new alloys was a little lower, but the tests indicated that the experimental alloys had the same or better properties in all other respects.[2]

A phase II program of more detailed experiments has been proposed to further verify the ability of bismuth/selenium to replace lead in this application.[3]

Outlook

The outlook for bismuth remains optimistic, especially as more development occurs in the area of nontoxic replacements for lead. Demand has increased slowly in recent years despite this optimism. Since bismuth is mainly a byproduct of lead, a rapid increase in supply is not likely, especially as the total consumption of lead remains somewhat flat. Some relief would be provided by the resumption of production at the Tasna Mine in Bolivia, the only significant primary source of bismuth.

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[1] Cohn, L. Bismuth-Tin Shot Receives Nod from Wildlife Agency. American Metal Market, v.103, no. 7, Jan. 10, 1995, pg. 5.

[2] Twarog, D. Modified Red Brass with Bismuth and Selenium Research, Final Report, American Foundrymen's Society, Des Plaines, IL, Mar., 1995.

[3] Twarog, D. Modified Red Brass with Bismuth/Selenium Phase II, American Foundrymen's Society, Des Plaines, IL, May, 1995.

TABLE 1
SALIENT BISMUTH STATISTICS 1/

(Metric tons)

	1990	1991	1992	1993	1994
United States:					
Consumption	1,120 r/	1,260 r/	1,300 r/	1,300 r/	1,470
Exports 2/	122	75	90	70	160
Imports for consumption	1,610	1,410	1,620	1,330	1,660
Price, average, domestic dealer, per pound	$3.56	$3.00	$2.66	$2.50	$3.25
Stocks, Dec. 31: Consumer	331 r/	247 r/	272 r/	323 r/	297
World:					
Mine production (metal content) 3/	3,440 r/	3,230 r/	2,740 r/	3,090 r/	3,020 e/
Refinery production 3/	4,190 r/	4,010 r/	3,670 r/	4,240 r/	4,100 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Includes bismuth, bismuth alloys, and waste and scrap.

3/ Excludes the United States.

TABLE 2
BISMUTH METAL CONSUMED IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1993	1994
Chemicals 2/	750 r/	841
Fusible alloys	256 r/	276
Metallurgical additives	232 r/	325
Other 3/	59	26
Total	1,300 r/	1,470

r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes industrial and laboratory chemicals, cosmetics, and pharmaceuticals.

3/ Includes other alloys and experimental uses.

TABLE 3
U.S. EXPORTS OF BISMUTH, BISMUTH ALLOYS, AND WASTE AND SCRAP, BY COUNTRY 1/

Country	1993		1994	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	38,500	$57	54,900	$98
Brazil	--	--	113	4
Canada	16,800	281	44,400	782
China	--	--	20,400	36
Costa Rica	969	12	--	--
France	140	13	--	--
Honduras	--	--	8,390	26
Hong Kong	--	--	4,150	17
India	--	--	247	3
Indonesia	100	5	--	--
Ireland	264	11	309	3
Japan	6,710	223	965	12
Korea, Republic of	54	3	200	3
Netherlands	--	--	18,800	17
Singapore	5,020	162	495	7
South Africa, Republic of	--	--	2,000	7
Taiwan	872	9	--	--
Thailand	--	--	272	4
United Kingdom	642	7	4,290	29
Other	39	7	119	12
Total	70,100	790	160,000	1,060

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF METALLIC BISMUTH, BY COUNTRY 1/

Country	1993		1994	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	275,000	$1,440	512,000	$3,150
Canada	40,600	194	145,000	743
China	264,000	1,240	80,100	543
Germany	849	50	5,890	78
Japan	--	--	1,670	81
Kazakhstan	69,300	211	38,500	128
Mexico	479,000	2,100	665,000	3,850
Morocco	--	--	158	3
Peru	117,000	564	115,000	637
Spain	7,240	92	3,010	36
Taiwan	500	6	--	--
United Kingdom	80,300	351	95,200	368
Other	--	--	77	32
Total	1,330,000	6,250	1,660,000	9,650

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 5
BISMUTH: WORLD MINE AND REFINERY PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

	Mine output, metal content					Refined metal				
Country	1990	1991	1992	1993	1994 e/	1990	1991	1992	1993	1994 e/
Australia e/	400	400	--	--	--	--	--	--	--	--
Belgium e/	--	--	--	--	--	1,000 r/	800 r/	800 r/	950 r/	900
Bolivia	68	--	--	--	--	137	--	17 r/	16 r/	16 3/
Bulgaria e/	45	40	40	40	40	45	40	40	40	40
Canada 4/	87	65	224	144 r/	131 3/	--	--	--	--	--
China e/	1,060 r/	1,040 r/	820 r/	740 r/	700	1,060 r/	1,260	1,060 r/	1,050 r/	1,000
France e/	70	50	--	--	--	--	--	--	--	--
Italy	--	--	--	--	--	34	45	20	5 r/	5
Japan 5/	133	138	159	149 r/	150	442	461	530	497 r/	500
Kazakhstan e/	XX	XX	35	30	25	XX	XX	45 r/	40 r/	35
Korea, Republic of 5/	79	42	9	5	--	79	42	9	5	--
Mexico 6/	733	651	807	908 r/	900	549	500 e/	550 e/	650 e/	650
Peru	555 e/	610 e/	550 e/	1,000 r/ e/	1,000	521	576	418	937 r/	900
Romania e/	40	55	50	40	40	35	50	50	35	35
Russia e/	XX	XX	5	4	4	XX	XX	10 r/	9 r/	9
Serbia and Montenegro 7/	XX	XX	10 r/	5 r/	5	XX	XX	20 r/	10 r/	10
Tajikistan e/	XX	XX	20 r/	15 r/	10	XX	XX	-- r/	-- r/	--
U.S.S.R. e/ 8/	80	70	XX	XX	XX	80	70	XX	XX	XX
United Kingdom e/	--	--	--	--	--	125	100	100	--	--
United States	W	W	W	W	W	W	W	W	W	W
Uzbekistan e/	XX	XX	15	10	10	--	--	--	--	--
Yugoslavia 7/ 9/	85	70	XX	XX	XX	85	70	XX	XX	XX
Total	3,440 r/	3,230 r/	2,740 r/	3,090 r/	3,020	4,190 r/	4,010 r/	3,670 r/	4,240 r/	4,100

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through Apr. 18, 1995. Bismuth is produced primarily as a byproduct of other metals, mostly lead ; Bolivia is the sole producer of primary bismuth.

3/ Reported figure.

4/ Figures listed under mine output are the metal content of concentrates produced.

5/ Mine output figures have been estimated based on reported metal output figures.

6/ Refined metal includes Bi content of imported smelter products.

7/ All production in Yugoslavia for 1990-91 came from Serbia and Montenegro.

8/ Dissolved in Dec. 1991.

9/ Dissolved in Apr. 1992.

BORON

By Phyllis A. Lyday

Boron is produced domestically only in the State of California. Boron products sold on the market are produced from a surface mine, underground mines, and from brine. The United States and Turkey are the world's largest producers of boron, changing positions from year to year. Boron is priced and sold on the boron oxide basis, which varies by ore and compound and on the absence or presence of sodium and calcium impurities. Boron exports are about one-half of domestic production.

Legislation and Government Programs

The California Desert Protection Act was signed into law on October 31. Under the Act, 2.7 million hectares (6.7 million acres) of public land would be designated as wilderness and be off limits to boron mining and mineral development. Death Valley National Monument was upgraded into a park and acquired an additional 526,000 hectares (1.3 million acres) that had been under the management of the Bureau of Land Management (BLM). There are patented claims to boron in the park. The new acreage makes Death Valley the largest national park in the lower 48 States. The Mojave National Preserve of 566,000 hectares (1.4 million acres) was upgraded from a BLM scenic area to a National Park Service preserve. Sports hunting and existing grazing and mining rights are permitted in the preserve. Congress continued to debate the fate of the Mining Law of 1872 as amended and its effect on the hard-rock mineral industry. Boron is leasable as sodium borate. Other colemanite and probertite minerals are locatable because they also contain calcium and are deposited as placer deposits, and therefore can be patented.

The Endangered Species Act continued to be a source of controversy. The desert tortoise was designated an endangered species in 1990 by the U.S. Department of the Interior, Fish and Wildlife Service (FWS). The listing extends long-term protection to the tortoise in 2.6 million hectares (6.5 million acres) Arizona, California, Nevada, and Utah. The areas listed include boron mineral areas being surface and underground mined and two solution-mining plants and one project area. Tortoise barriers have to be installed along the perimeter if rock impediments and natural terrains alone are not sufficient to prevent tortoise passage. Any changes to land use require consultation with the FWS beforehand. BLM announced a final rule to implement a congressional requirement that holders of unpatented mining claims pay the Government a $100 rental fee per claim for 1993-94. The new rental fee was to discourage mining claims where the claimant had no intent to mine. The fee will also reduce unnecessary disturbance of the land just to retain rights to mining claims. The new rules are for the periods September 1, 1992, through September 1, 1993, and September 1, 1993, through September 1, 1994. The rental requirements are temporary and must be renewed by Congress. Small miners with 10 or fewer claims and that meet certain other criteria are exempt from the fee.[1]

The National Toxicology Program (NTP) listed fiberglass on its list as a material reasonably anticipated to be a carcinogen. NTP based its decision on animal studies where glass fibers were surgically implanted or injected into rodent lungs and abdomens, resulting in tumors. Makers of fiberglass believe that the animal studies using artificial means of exposure do not establish a human health risk. Research involving humans and multiple studies in which animals breathed fiberglass showed no association between exposure to fiberglass and cancer. The Secretary of the Department of Health and Human Services stated that the listing of a substance is only an initial step in the risk assessment process. Manufacturers voluntarily added a warning label to fiberglass products in 1988, and no additional label changes will be required.[2]

The U. S. Environmental Protection Agency (EPA) may expand the Toxic Release Inventory (TRI) to include mining during 1994. On January 12, 1994, the Federal Register listed 313 chemicals and chemical categories that were added to the TRI list, including boron trichloride and boron trifluoride.

EPA issue a Reregistration Eligibility Decision under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended in 1988, in the Federal Register on March 17, 1994, for boric acid, deca- and penta-hydrate borax, anhydrous borax, disodium octaborate tetrahydrate, and sodium metaborate. The accelerated reregistration program determined that all currently registered products containing these active ingredients are eligible for reregistration.

In 1993, the Internal Revenue Service (IRS) announced new rules that give U.S. taxpayers guidance on new pricing rules associated with intercompany transactions. For many mining companies, transactions would use the comparable uncontrolled price (CUP) method. CUP is based on identifiable transactions with unrelated parties involving "substantially the same" property and circumstances. Policy compliance were reinforced in 1993 by Congress by assessing a penalty on underpricing or overpricing intercompany transactions.[3]

Production

Domestic data for boron are developed by the United States Bureau of Mines (USBM) from two separate, voluntary surveys of U.S. operations. The majority of boron production continued to be from Kern County, CA, with the balance from San Bernardino and Inyo Counties, CA. Of the three operations to which a sold and used survey request was sent, three responded, representing 100% of the total boron sold or used. *(See tables 1, 3, and 4.)*

American Borate Co. (ABC) continued to mine small amounts of colemanite and ulexite/probertite from the Billie Mine. Colemanite was processed at Lathrop Well, NV. Storage and grinding facilities were at Dunn, CA. (See table 2.)

North American Chemical Co. operated the Trona and Westend plants at Searles

Lake, in San Bernardino County, to produce refined sodium borate compounds and boric acid from the mineral-rich lake brines. North American is owned by the Harris Chemical Group, with corporate headquarters in New York, NY, and operating headquarters in Overland Park, KS. Boron chemicals saw an increase with volumes of 35,500 metric tons for the quarter ending June 25, 1994, compared with 35,200 tons in 1993. The average price was up to $513 per ton from $501. Total sales were $18.1 million compared with $17.6 million.[4]

At the Trona plant, a differential evaporative process produced borax with potash as a byproduct. Boric acid was produced by solvent extraction. The Westend plant used two lines to supply brines to the plant. The first line fed lake brine to the Argus plant where sodium carbonate was produced. The effluent borax-rich brine then is pumped to the Westend plant where it supplied about two-thirds of the brine feed. The effluent was blended with fresh lake brine from a second feed line that supplied about one-third of the brine feed. The blended brine was then cooled to 18° C to precipitate decahydrate borax. The effluent was cooled to 8° C, and the precipitated Glauber's salt was used to produce sodium sulfate. North American was in the process of evaluating technical changes in its production operation.

U.S. Borax, Inc. (Borax), a part of Borax Consolidated Ltd. of the RTZ Corp. PLC of London, United Kingdom, continued to be a primary world supplier of sodium borates. RTZ reported that production of borates for the first half of 1994 was 255,000 tons of boron oxide compared with 229,000 tons for the first half of 1993.[5]

Processing at Borax's open pit mine include crushing of the ore, dissolving of the borax from the claystone, liquid/solid separation, crystallization of refined products from liquors, drying, storage, and shipping.

Borax mined and processed crude and refined sodium borates, its anhydrous derivatives, and anhydrous boric acid at Boron, in Kern County, CA. A second plant at Boron used a proprietary process to produce technical-grade boric acid from Borax's extensive kernite ore reserves. Both plants are International Organization for Standardization (ISO) registered.

Liquid waste from the plant is pumped to impoundment pond and evaporated. The 14 million tons of pond material contains 1.5 million tons of boron oxide. A new process has been developed to process the plastic pond material, which after solar drying continues to be pliable. The plastic pond material can be dried, crushed, and screened. The borate ore is separated from montmorillonite claystone using high intensity magnetic separators. The weak attraction of montmorillonite to a magnet is enhanced by the presence of small percentages of pyrrhotite (FeS) in the matrix of the claystone. The starting grade from the ponds is concentrated to over 26% boron oxide using the process. The concentrate is acceptable as feed to the existing refinery and is competitive with the mined ore. At present, over 52% of the boron oxide in the pond can be recovered by the screening and magnetic separation method. The waste from the dry beneficiaton process can be deposited with other overburden and mine waste.[6]

The majority of material was shipped to Borax's storage in Wilmington, CA. Products made at Wilmington included ammonium borates, potassium borates, sodium metaborates, and zinc borate.

Consumption

U.S. consumption of borates increased. Glass account for three major borate applications as follows: glass fiber insulation, borosilicate glass, and textile glass fiber. A USBM canvass of the three U.S. producers also collected data on domestic consumption of boron minerals and compounds shown in tables 3 and 4.

The use of borates in glass fiber thermal insulation, primarily used in new construction, was the largest area of demand for borates and the principal insulating material used in the construction industry. Composed of very thin fibers spun from molten glass, its purpose is to trap and hold air. Typically between 4% and 5% boron oxide is incorporated in the formulation to aid melting, inhibit devitrification, and improve the aqueous durability of the finished product. Cellulosic insulation, the seventh largest area of demand for borates, increased.

Borate demand also increased in the fourth major market, manufacturing high-tensile--strength glass fiber materials for use in a range of products. The process of producing glass fiber uses a borosilicate e-glass formulation that is continuously drawn through platinum alloy bushings into continuous filaments of between 9 to 20 microns in diameter. The plastic industry uses roving or chopped strand fibers and the textile industry uses yarn fibers.[7] E-Glass, or textile fiber glass, typically contains between 6% and 8% boron oxide. Originally these glasses were used for electrical purposes, and low sodium levels were important. Now its major applications are reinforcements for plastics, but the low sodium tolerance still applies. The nonconductive and low dielectric properties of high-strength glass-reinforced materials make them transparent to radar and thus valuable for "stealth" applications. Carbon-fiber-reinforced resins can be stronger than metals and, with higher modules, more stable. Although composites can be 10 times more expensive than typical aerospace-grade aluminum, the flexibility they offer in design and consolidation of parts allows large, complex structures to be fabricated to exacting specifications. In addition, its light weight and ability to withstand high temperatures have made them the material of choice for a variety of aerospace applications.

Owens-Corning Fiberglas Corp. reopened its Jackson, TN, glass fiber plant. Capital investment was between $30 and $40 million to install new equipment. When the plant reopened in 1994, it employed about 80 people and produced wet-process mat glass fiber for use in making roofing shingles.[8]

Consumption of borates in borosilicate glasses remained the third major end use, and demand decreased. Boron added in amounts of between 10% and 13% to glass reduced the viscosity of the melt, assisted with fiber formation during processing, allowed for improved specific optical properties, increased resistance to aqueous or chemical attack, enhanced certain mechanical properties, and reduced the thermal expansion coefficient and thermal shock resistance of the product. Scientific glassware products are usually fabricated in Pyrex borosilicate glass. This type of glass is resistant to heat up to 400° C and to chemical corrosion from liquids and gases.[9]

Construction of the Nation's first facility to produce a borosilicate glass from solid nuclear waste began at Savannah River Site, Aiken, SC. High-level nuclear waste that has accumulated during 35 years will be reprocessed and stored in stainless steel canisters for temporary storage before interment in a geologic repository. Boron and lithium are added to the sludge to improve the viscosity of the glass. The viscosity of the borosilicate glass is a function of temperature. Viscosity determines the rate of melting of the raw feed, the rate of glass bubble release (foaming and fining), the rate of homogenization, and therefore, the quality of the final glass product. If the viscosity is too low, excessive convection currents can occur, increasing corrosion and erosion. After vitrification at 1,150° C, the glass is pored into the stainless steel canisters for interim storage.[10]

Boron compounds continued to find application in the manufacture of biological growth control chemicals for use in water treatments, algicide, fertilizers, herbicides, and insecticides. Boron can be applied as a spray and incorporated in herbicides, fertilizers, and irrigation water. Boron is a micronutrient essential to crop growth. Liming acid soils sometimes produces a temporary boron deficiency and can increase boron application rates needed for optimum plant growth if the pH is above 6.5.[11]

A growing and important use of zinc borate, ammonium pentaborate, and boric oxide is as fire retardants in the cellulosic materials such as chipboard, cellulose insulation, and cotton mattresses. Zinc borate is of commercial importance in synthetic polymers.

Boron compounds also were used in metallurgical processes as fluxes, shielding slag in the nonferrous metallurgical industry, and components in electroplating baths. Small amounts of boron and ferroboron were constituents of certain nonferrous alloys and specialty steels, respectively.

The alloys of the nonmetal boron and the metals neodymium and iron produces the strongest magnetic material known. The magnets then are used in automotive direct-current motors, computer disk drives, portable power tools, and home appliances.[12]

Boron also is used as a bleaching agent in detergents and cleaning products, such as compact washing powders. Perborates carry active oxygen that forms hydrogen peroxide in solution. Perborate tetrahydrate has been displaced by perborate monohydrate, which is more soluble in cool laundry wash temperature conditions. E. I. du Pont de Nemours & Co. Inc. (Dupont) announced plans to sell its 32-million-killogram-per-year sodium perborate business to Degussa A.G. Dupont will shutter its unit at Memphis, TN. Degussa and Solvay Interox are now the leading U.S. suppliers, but only Interox has domestic production at Deer Park, TX.[13] *(See tables 3 and 4.)*

Research attempts have been made at recycling fiber-reinforced plastics, but at present it is not economical. In 1992, Canada's Environmental Ministry funded a recycling plant reportedly to be the first of its kind in North America. The facility will create new raw materials from old fiberglass boat hulls, bathtubs, and auto parts by separating the glass fibers from the resins.

Prices

The price for ultra high-purity boron oxide increased. All other reported prices decreased. *(See table 5.)*

European prices of boron minerals were listed as $290 to $360 per ton for Turkish lump colemanite, 40% to 42% boron oxide content, FOB. Argentinean natural colemanite was listed as $360 to $400 per ton at 40% to 42% boron oxide content ground and bagged.[14]

Exports of borates from Chile list average unit value per ton as follows: boric acid, $511.80; ulexite, $120; and refined borax, $416.70.

Foreign Trade

The majority of material from the Borax facility in Boron was shipped to storage, loading, and shipping facilities at Wilmington, CA. A large part of the output was exported to Western Europe from Wilmington to Botlek, Netherlands. ISO 9000 registration has been achieved at Borax NV, the bulk borate terminal at Rotterdam, and at the Coudekerque, France, boric acid plant. *(See tables 6 and 7.)*

World Review

Argentina.—The Argentina Mining Plan changed the collection of taxes to encourage foreign investment. Under the new laws, the Federal Government offered mining companies a tax regime that provides for a 30% corporate tax rate, with a guaranteed cap at this level for 30 years. Corporations will also be able to write off all exploration costs against future corporate tax once the project begins generating profits. Companies will be allowed to set up free trade zones in which remaining tax and import restrictions will be waived.[15] *(See table 8.)*

FMC Corp. planned to develop a lithium and boron production facility at the Salar del Hombre Muerto in the northern region because of the new mining plan. FMC plans to utilize new extraction technologies for the brine that will be developed from the salar.

Boroquimica SA continued production of tincal from the Salar del Hombre Muerto and boric acid from Tincalayu in Salta Province. Tincal between 16% and 18% boron oxide is concentrated by washing and crystallizing to a 99.9% borax product. At Sijes in Salta Province, hydroboracite and colemanite are produced. Ulexite is produced by Boroquimica at Cauchari in Jujuy Province and at Diablillos in Salta Province.[16]

Austria.—Degussa and Treibacher Industrie have formed a 51-49 joint venture to manufacture perborates for use in detergent powders. The new company is called Aktivsauerstoff.[17]

Bolivia.—Corban, S.A., a division of Empresa Minera Industrial, processed ulexite into borax decahydrate and pentahydrate. Annual capacity is 200 tons of deca- and 100 tons of penta-hydrate. Future plans include boric acid production. The mine, located in the Salar de Uyuni, a dried salt lake, began production in 1990. The processing plant is located in Oruro. The plant and mine employs 40 full-time employees and 200 part-time employees.[18] Compania Minera Tierra Ltd., a small company formed in 1988 for producing borates in an area of the Department of Potosi, has important concessions of ulexite and sulfur near the Chilean border in the southwestern tip of the country. About 120,000 tons per year of ulexite is exported to Brazil and other neighboring countries. In 1990, the company employed 120 persons. In 1993, a boric acid plant was operational and producing 10,000 tons per year.

The company has interest in ulexite mineral concessions that cover an area of 4,800 hectares, and reserves have been estimated by the company to exceed 13 million tons of raw ulexite with grades ranging from 20% to 37% boron oxide content. Ulexite is extracted and dried by plowing with a tractor. The dried ulexite is washed and roasted. The processed ulexite of about 42% boron oxide content is bagged and exported by trucks and rail.

Various borate deposits are in the southwestern part of the Altiplano. Llipi, in the south of Salar de Uyuni, contains an estimated 12 million tons of ulexite. Copla Ltda. was mining ulexite for export. Production of ulexite was about 9,600 tons.[19]

Canada.—High purity boric acid from Russia began to be sold through Amalgamet Canada, a division of Premetalco Inc. The acid contain 99.6% to 99.9% boron oxide.[20]

Chile.—Boratom Quimica Processes Ltda. operates a refining plant near Iquique. In March 1992, Boratom's assets and technology were sold to Boron International Inc. (Canada). In November 1993, Boron entered into an agreement with Teck Corp. called Boron Chemicals Processes Chile S.A.[21]

Quimica & Industrial del Borax Ltda. (Quiborax) was the main producer of boric acid and concentrated ulexite. Quiborax operated a mine at Surire, Parindacta, with a crude annual output of 1 million tons per year of ulexite. The ulexite is washed and upgraded from 30% to 40% boron oxide by centrifugal action and flotation prior to filtration. Calcium borate production ceased in March 1994. The boric acid production was estimated to be 20,000 tons with plant facilities at El Aguila, Arica.

The National Boraxx Corp. (Cleveland, OH) packages and distributes boric acid in the United States for Quiborax.

During 1993, North American was reported to have attempted to purchase Quiborax. Although the purchase failed to materialize, there was discussion of an agreement for North American to market product.[22]

Compania Minera Salar de Atacama (Minsal) is a joint-venture project between Sociedad Quimica y Minera de Chile SA (SQM), 75%, and Corporacian de Fomento de la Produccion (CORFO), 25%, at the Salar de Atacama. The first stage of the project is a $90 million potassium chloride production facility to be constructed by 1996. The second stage involves lithium carbonate production to begin in 1997. The final stages involve potassium sulfate and boric acid production to be constructed at such time that the overall project is yielding a profit. The company is surveying new ore deposits that could replace the Maria Elena and Pedro de Valdivia plant locations within a decade.[23]

China.—The borates in the salt lakes of China are mainly found on the Qinghai-Xizang (Tibet) Plateau. The waters contain a mean value 85 milligrams per liter of boron oxide. The maximum value of boron oxide is 1,516 milligrams-per-liter.[24]

In Liaoning Province, reserves were reported at 44 million tons of boromagnesite with 8.4% boron oxide content. Production was reported as 77,000 to 110,000 tons per year of borax and 10,000 to 18,000 tons per year of boric acid at the following production sites: Liaoning, Jilin, Qinghai, and Tibet. Exports of borax were reported to be 2,325 tons during 1992 valued at $790,000.[25]

A Chinese company was to process 120,000 tons of boron-iron ore following recent success to separate the boron from the ore. The deposits in the Liaoning Province represents 64% of the country's total boron resources and 90% of these deposits are associated with iron.[26]

Europe.—Total individual end-use breakdown of consumption of boron oxide in Europe during 1992 was 186,000 tons reported in tons was as follows: enamels and glazes, 70,000; insulation fiber glass, 41,000; textile fiber glass, 35,000; and other glass, 40,000.[27]

Boron occurs naturally in fruit and vegetable, yet some European Union (EU) members seek to replace existing safety levels in the 1980 drinking water directive with World Health Organization (WHO) standards. Sodium perborate used in household detergents is discharged into rivers via sewers. Current directives limit boron in potable water to 1 mg/l (mg/l), but WHO recommends a limit of 0.3 mg/l.[28]

A new international association is being formed to serve industrial minerals interests in Europe named Industrial Minerals Association (IMA-Europe). The four founding members representing various industry sectors of talc, silica, borate, and calcium carbonate. Borax Consolidated represents the borate interest. IMA-Europe is being established to study all noncommercial issues concerning those industrial minerals interests represented in the association, i.e., scientific, technical, documentary, and institutional fields.[29]

India.—Submarginal borax reserves of 74,200 tons have been estimated in Leh District of Jammu and Kashmir. Occurrences are also known in Surendra Nagar District of Gujarat and Jaipur and Nagaur Districts of Rajasthan. Domestic requirements of boron minerals are met solely by imports. Borax Morarji Ltd., Bombay, was engaged in refining imported crude borates from the United States and Turkey to produce borax and boric acid. Capacity was reported to be 17,000 tons per year for borax and 3,000 tons per year for boric acid. During 1990-91, the company treated 15,848 tons of crude borates to produce 13,052 tons of borax and 3,180 tons of boric acid. National Peroxide Ltd., Bombay, produced 85 tons of sodium perborate. Southern Borax Ltd., Madras, which has a capacity of 15,000 tons per year of borax, remained closed in 1990-91. Consumption of the refined borax during 1990-91 was reported to be total 9,200 tons in the following industries: Ceramic, 2,200; chemical, 100; glass, 6,600; graphite crucible, 100; and other, 200.[30]

Kazakhstan.—Boron minerals also were reported to be produced in Kazakhstan, the second largest newly independent republic of the former U.S.S.R. The Government was actively pursuing foreign investment to increase production capacity by improving efficiency to increase exports. The decision by the Republic of Kazakhstan to invite bids on these properties at this time reflects its keen interest to attract mineral exploration and mining companies as a matter of high national priority. A considerable amount of information was assembled on each of the properties that were available through a tender program. Two boron deposits listed in the tender were Inderskaya with 33.7 million tons of 2.15% boron oxide as boracite and hydroboracite under a gypsum cap rock, which also contains potassium oxide. The borates are concentrated in four deposits, 1 to 10 meters in thickness and up to 2 kilometers long. The other deposit Satimola is similar to the Inder borates, nodules and veins of hydroboricite and ulexite, at the gypsum/clay interface above another salt intrusion. The grade is listed as 9.15% boron oxide, in three bodies totaling 43 million tons.[31]

Netherlands.—Morton International planned to transfer sodium hydride manufacturing operations from Beverley, MA, to Delfzijl where Morton now produces sodium borohydride. When the plant is completed in 1994, Morton planned to stop production in the United States and supply that market from the Delfzijl plant.[32]

The Silenka glass fiber factory in Hoogezand, was founded in 1961 as a joint venture between PPG and Akzo. The state-owned Development Co. for the Northern Netherlands assisted by purchasing a 30% share in 1977 when the company was struggling because of rising energy costs. PPG purchased the remaining shares in 1990 and renamed the site PPG Industries Fiber Glass bv. PPG is the second biggest fiberglass manufacturer in Western Europe.

BV Pharmacie Holland, Holland, was also a source of boric acid, boric oxide, calcium borate, borax decahydrate, sodium borate, and sodium perborate in Europe.

Peru.—The quantity and number of minerals produced in Peru and the likelihood of significant deposits to be discovered attracted attention to the privatization plants. The Government continued its privatization program to reactivate the entire mining sector selling many properties at prices below comparable resources in the international market. Boron continued to be produced in Arequipa by Compania Minera Ubinas S.A. A total of 34 tons of sodium borate and sodium calcium borates was imported by Fertilizer Corp. of America into Miami, FL, and Wilmington, NC.

Russia.—Primorsky Industrial Amalagmation, in Dalnegorsk, produces boron minerals from datolite containing between 6% and 12% boron oxide.

Total boron oxide production for the Dalnegorsk region was listed as 140,000 tons boric acid, 13,000 tons calcium borate, 2,500 tons of decahydrate borax, and 15,000 tons other. The Dalnegorsky plant supplied 85% of the domestic market. Design capacity of the plant is 250,000 tons per year of bric acid.[33]

Amalgamation is part of the Russian Agricultural Joint Stock Co. known as ROSAGROCHIM. ROSAGROCHIM coordinates the activities of about 100 companies.

Turkey.—Turkey's boron operations are under the control of the Government corporation Etibank. Ulexite is mined at Bigadic; colemanite at Bigadic, Emet, and Kestelek; and tincal at Kirka. Etibank was reported to have an ore production capacity of 8,000 tons of colemanite, 500,000 tons of tincal, and 115,000 tons of ulexite. Etibank operates refining facilities to produce refined sodium borates and boric acid from tincal concentrates at Bandirma and Kirka. Boron minerals and compounds are shipped from the Port of Bandirma on the Sea of Marmara and Izmir on the Aegean Sea. Bandirma can produce 55,000 tons of borax, 35,000 tons of boric acid, and 20,000 tons of sodium perborate per year. Kirka can produce 50,000 tons of borax, 160,000 tons of pentahydrate borax, and 50,000 tons of anhydrous borax per year.[34]

The Government announced that Etibank would become two separate divisions as a prelude to privatization of the banking business. Sixty days after the July 13 announcement, the two divisions became affiliated companies, and the process will begin for privatization of the banking division.

The Turkish Government now owns all boron and trona mineral deposits, and private concessions of these minerals could not be sold to private investors. Boron is a profitable operation for Etibank and the privatization of this sector is unlikely.[35]

Private processing of boron reserves from stockpiles and dumps have occurred for the past decade. One such company, Rasih ve Ihsan Maden sought capital to expand its processing of 3 million tons of boron reserves.[36]

United Kingdom.—On June 17, Borax Consolidated, a subsidiary of RTZ Corp., opened a technical center at the University of Surrey Research Park, near Guildford. The intention is to combine research and development activities with the head office and marketing administration functions, while drawing on the University for ideas and inspiration.[37]

Imperial Chemical Industires Plc planned to close the 38,000 ton-per-year sodium perborate plant at Runconrn at yearend. The remaining sodium perborate demand will be supplied by German producer Degussa and Netherlands produce Interox S.A. with 285,000 and 240,000 tons per year of capacity, respectively.[38]

Current Research and Technology

Scientists at Westinghouse Hanford Company are using a salt process to extract nonradioactive sodium nitrate from mixed waste stored as saltcake in underground storage tanks. Water and nitric acid are combined with the mixed radioactive waste and evaporated to produce sodium nitrite. The radioactive waste can be reduced to 10% of the previous volume and shipped to a permanent storage site. The sodium nitrate can be recycled for use by industry. The radioactive waste is vitrified into a borosilicate glass. The Hanford Site alone could have reductions of 25 to 45 million gallons of mixed waste, reducing the need for waste storage and saving billions of dollars.[39]

Stabilizing surplus plutonium as borosilicate glass may be the fastest and surest way of disposal. Several unresolved technical issues with plutonium vitrification have been identified, but are within the real of solvable solutions. Other recommendations include burning the fuels in existing reactors and using the fuel in long-rang energy programs. Spent fuels from using the plutonium as fuel would need to be recycled or stored. Studies continued on the stabilization although the use of geologic repositories for storage have critical safety concerns and would require international safeguards into perpetuity.[40]

The USBM in cooperation with the American Society of Mechanical Engineers conducted over 200 hours of melting tests to vitrify residues from five municipal waste combustion facilities. Each of the residues underwent magnetic separation, screen size analysis, and bulk chemical analysis prior to melting. The chemical composition of the residues ranged between 47 and 257 part per million of boron.[41]

Herbert C. Brown and P. V. Ramachandran lectured on "Recent Advances in the Boron Route to Asymmetric Synthesis" at the IMEBORON VIII-8th International Meeting on Boron Chemistry. Completion rates of 95% are available for a variety of asymmetrical syntheses using simple and convenient reagents.[42]

Two French scientists reported that boron in meteorites and on Earth may be the product of pre-solar-system collisions between interstellar hydrogen and low-energy cosmic rays. This theory is because the $_{11}B$ to $_{10}B$ ratio in the solar system, around 4, is too high to be explained by current chemical evolution models of the galaxy that would put the ratios at 2.5.[43]

An electrodeposited nickel-tungsten-boron alloy coating has been developed that has physical and chemical properties equal or superior to those of chromium. The coating deposition takes place in a mildly alkaline solution and is easy to operate and control.[44]

Quantum-mechanical methods and supercomputers were used to analyze the effects of two impurities in steel, phosphorus, and boron, on steel's atomic integrity. Boron is added in small amounts to harden the steel. The destabilizing effects of the impurities on steel's "crystal grain boundaries" were calculated. With a clear understanding of the mechanisms of embrittlement, new steels can be designed that minimize the deleterious effects.[45]

A fiber-reinforced polymer and inexpensive polymer coatings can be mixed with boron to bond to the original polymer seamlessly. The new low-cost materials could replace or be mixed with expensive engineering plastics to enhance strength.[46]

A new fiber resulting from the new biocomponent technology is composed of two different forms of glass fused together in a single filament. The new glass will be marketed as a home attic insulation. The new fiber has a random irregular twist that forms as the two glasses combined. The fiber cards well and it has potential for blending with other types of fibers in textiles and composites.[47]

The effects of saline water containing boron, sodium, and calcium chloride, were studied by the University of California's West Side Field Station in the San Joaquin Valley at Fresno. For the first 7 years of the 10-year test, 900 almond trees were given different amounts of salty water. For the final 3 years, one-third of the trees were given clean water. The study suggests that toxic levels saline water build up in the soil to reduce the almond yields. Leaf damage on trees that had been irrigated only with saline water was likely a result of chloride, not boron or sodium.[48]

A paper that discussed the types of boron minerals being processed and the chemical and physical treatments of the ores was presented. Boron minerals of economic importance are primarily colemanite, tincal, and ulexite. Turkey and the United States are the leading producers of boron minerals and compounds. Other production includes datolite in Russia. The major physical treatments are optical sorting, attrition scrubbing, dense medium concentration, and floation. Sulfonates were the most common type of collectors used in floations.[49]

Outlook

Production of boron minerals and compounds have decreased between 1990 and 1994. One reason is that production and imports reported in 1 year may be utilized over a period of years. In addition, environmental concerns may change the demand for boron significantly in a short period. The regulation of fire retardants in products has resulted in changes in boron usage as a fire retardant. More recent decreases in domestic consumption have been attributed to decreases in glass consumption because of less demand resulting from a recession. Moreover, one-half of domestic production is exported. Because of increases in production in other countries, this amount has decreased significantly during the past few years.

Agriculture.—Boron usage in agriculture increased significantly in 1994. Farming exports are showing increased strength, and demand for boron usage in agriculture is expected to increase.

Ceramics and Glass.—Reported consumption of boron minerals in glass and ceramic uses was 150,400 tons of boron oxide content representing 51% of total demand. This was down from the 211,656 tons representing 60% of total demand in 1993. Ceramics and glass have faced competition with polymers. The U.S. fiberglass industry was reported to be feeling the effects of recessionary pressures. The sagging economy produced a decline in demand for fiberglass reinforcements. Fiberglass is closely related to construction and transportation and is expected to decrease.

Coatings and Plating.—Primarily used as a protective coating for steel products and as a glazing on ceramic tiles, boron usage increased 50% during the year. Future for this use is expected to increase during 1995.

Fabricated Metal Products.—Boron usage increased in metal products during the year. Usage in specialized metal was expected to increase.

Soaps and Detergents.—Usage in soaps and detergents increased. Recent concern for environmental effects of chlorine has reversed the decline. Perborate bleaches have returned to name brand soap products. The usage of boron in soaps and bleaches was expected to increase by 4% per year during the next 5 years.

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TABLE 1
SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Sold or used by producers:					
Quantity:					
Gross weight 2/	1,090	1,240	1,010	1,060	1,110
Boron oxide (B2O3) content	608	626	554	574	550
Value	$436,000	$443,000	$339,000	$373,000	$443,000
Exports:					
Boric acid: 3/					
Quantity	39	47	80	75 r/	87
Value	$31,700	$35,500	$53,700	$50,500	$53,300
Sodium borates:					
Quantity	585 4/	554 5/	489 5/	481 5/	498 5/
Value	$208,000 e/	$206,000 e/	$159,000 5/	$181,000 5/	$165,000
Imports for consumption: 5/					
Borax:					
Quantity	5	10	16	40	9
Value	$1,570	$3,260	$5,330	$1,230	$2,700
Boric acid:					
Quantity	6	5	6	17	20
Value	$3,920	$3,780	$4,340	$11,900	$12,900
Colemanite:					
Quantity	12	18	30	90	27
Value	$3,310	$4,390	$16,100	$48,600	$10,800
Ulexite:					
Quantity	29	16	42	149	120
Value	$7,360	$4,060	$11,300	$40,700	$24,000
Consumption: Boron oxide (B2O3) content	319	262	345	321 r/	296
World: Production	2,910 r/	2,960 r/	2,680 r/	2,670 r/	2,850 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Minerals and compounds sold or used by producers, including both actual mine production and marketable products.

3/ Includes orthoboric and anhydrous boric acid.

4/ Source: The Journal of Commerce Port Import/Export Reporting Service.

5/ Source: Bureau of the Census.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE 1/

Mineral	Chemical composition	B2O3 weight percent
Boracite (stassfurite)	Mg6B14O26Cl2	62.2
Colemanite	Ca2B6O11 • 5H2O	50.8
Hydroboracite	CaMgB6O11 • 6H2O	50.5
Kernite (rasortie)	Na2B4O7 • 4H2O	51.0
Priceite (pandermite)	CaB10O19 • 7H2O	49.8
Probertite (kramerite)	NaCaB3O9 • 5H2O	49.6
Sassolite (natural boric acid)	H3BO3	56.3
Szaibelyite (ascharite)	MgBO2(OH)	41.4
Tincal (natural borax)	Na2B4O7 • 10H2O	36.5
Tincalconite (mohavite)	Na2B4O • 5H2O	47.8
Ulexite (boronatrocalcite)	NaCaB5O9 • 8H2O	43.0

1/ Parentheses include common names.

TABLE 3
U.S. CONSUMPTION OF BORON
MINERALS AND COMPOUNDS, BY END USE

(Metric tons of boron oxide content) 1/ 2/

End use	1993 r/	1994
Agriculture	14,800	21,200
Borosilicate glasses	64,500	27,400
Enamels, frits, glazes	10,300	15,400
Fire retardants:		
Cellulosic insulation	9,670	15,800
Other	286	1,360
Insulation-grade glass fibers	106,000	97,000
Metallurgy	1,870	1,950
Miscellaneous uses	32,600	23,800
Nuclear applications	8,870	395
Soaps and detergents	13,800	14,000
Sold to distributors, end use unknown	37,200	51,300
Textile-grade glass fibers	21,300	26,000
Total	321,000	296,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes imports of borax, boric acid, colemanite, and ulexite.

TABLE 4
U.S. CONSUMPTION OF ORTHOBORIC ACID 1/ 2/, BY END USE

(Metric tons of boron oxide content)

End use	1993 r/	1994
Agriculture	484	493
Borosilicate glasses	13,500	5,440
Enamels, frits, glazes	2,860	1,790
Fire retardants:		
Cellulosic insulation	1,760	5,070
Other	285	1,360
Metallurgy	219	205
Miscellaneous uses	11,200	9,390
Nuclear applications	8,850	395
Soaps and detergents	1,560	--
Sold to distributors, end use unknown	13,700	23,500
Textile-grade glass fibers	7,490	12,200
Total	61,900	59,800

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes imports.

TABLE 5
YEAREND 1994 PRICES FOR BORON MINERALS AND COMPOUNDS PER METRIC TON 1/

Product	Price, Dec. 31, 1993 r/ (rounded dollars)	Price, Dec. 31, 1994 (rounded dollars)
Borax, technical, anhydrous, 99%, bulk, carload, works 2/	761 - 769	720
Borax, technical, anhydrous, 99%, bags, carload, works 2/	837	765
Borax, technical, granular, decahydrate, 99%, bags, carload, works 2/	315 - 446	302
Borax, technical, granular, decahydrate, 99.5%, bulk, carload, works 2/	265	257
Borax, technical, granular, pentahydrate, 99.5%, bags, carload, works 2/	354 - 420	339
Borax, technical, granular, pentahydrate, 99.5%, bulk, carload, works 2/	304	294
Boric acid, technical, granular, 99.9%, bags, carload, works 2/	807 - 815	753
Boric acid, technical, granular, 99.9%, bulk, carload, works 2/	757	708
Boric acid, United States Borax & Chemical Corp., high-purity anhydrous, 99% B_2O_3, 100-pound-bags, carlots	1,367	1,813
Colemanite, Turkish, 42% B_2O_3, ground to a minus 70-mesh, f.o.b. railcars, Kings Creek, SC 3/	656	NA
Ulexite, Turkish, 38% B_2O_3, ground to a minus 6-mesh, f.o.b railcars, Norfolk, VA 3/	332	NA

r/ Revised. NA Not available.

1/ U.S. f.o.b. plant or port prices per metric ton of product. Other conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and/or somewhat different price quotations.

2/ Chemical Marketing Reporter. V. 245, No. 1, Dec. 1993, p. 24; V. 247, No. 1, Dec 1994, p. 27.

3/ American Borates Co.

TABLE 6
U.S. EXPORTS OF BORIC ACID AND REFINED SODIUM BORATE COMPOUNDS, BY COUNTRY 1/

Country	1993			1994		
	Boric Acid 2/			Boric Acid 2/		
	Quantity (metric tons)	Value (thousands)	Sodium borates 3/ (metric tons)	Quantity (metric tons)	Value (thousands)	Sodium borates 3/ (metric tons)
Australia	1,240	$997	7,150	1,600	$895	6,790
Belgium	--	--	3,670	66	26	1,910
Brazil	2,010	784	509	2,320	795	488
Canada	5,500	3,620	33,200	7,250	4,860	39,600
Colombia	115	103	2,840	182	156	2,930
France	313	438	40	4,390	1,020	83
Germany	27	11	52	2,000	1,550	5
Hong Kong	871	485	2,610	963	559	3,280
India	--	--	5,220	--	--	620
Indonesia	2,600	1,680	7,590	2,720	1,430	11,400
Israel	61	54	243	89	58	186
Japan	22,300	18,200	25,900	14,500	12,500	27,600
Korea, Republic of	9,700	6,150	14,700	11,900	6,950	15,000
Malaysia	1,990	972	4,920	3,440	1,590	6,430
Mexico	3,900	2,690	25,600	6,740	3,420	22,800
Netherlands	3,140	3,080	257,000	5,950	6,200	263,000
New Zealand	275	171	2,970	218	118	2,370
Philippines	2,510	561	1,290	2,050	530	1,500
Singapore	1,330	641	2,190	884	391	1,950
South Africa, Republic of	92	94	321	375	192	649
Spain	2,410	1,170	54,400	5,420	2,100	63,400
Taiwan	10,800	6,370	9,590	10,200	5,320	10,500
Thailand	1,760	1,250	5,040	2,380	1,650	6,810
United Kingdom	243	206	9,310	125	92	673
Venezuela	810	497	1,310	403	264	984
Other	519	281	3,120	1,190	613	6,750
Total	74,500	50,500	481,000	87,400	53,300	498,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ HTS code No. 2810.00.0000.
3/ HTS code Nos. 2840.19.0000, 2840.30.0000, and 2840.20.0000.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF BORIC ACID, BY COUNTRY 1/

	1993		1994	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Bolivia	318	$137	2,120	$1,030
Canada	64	56	--	--
Chile	5,170	3,400	6,170	3,380
China	17	12	30	29
France	4	11	5	19
Germany	34	40	20	28
Italy	9,350	6,900	5,650	3,990
Japan	159	212	134	186
Netherlands	205	134	41	26
Norway	1	3	--	--
Russia	235	298	470	484
Switzerland	11	8	1	1
Taiwan	4	3	--	--
Turkey	1,000	473	4,980	3,720
United Kingdom	167	217	25	38
Total	16,700	11,900	19,600	12,900

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ U.S. Customs declared values.

Source: Bureau of the Census.

TABLE 8
BORON MINERALS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Argentina	144 r/	116 r/	125 r/	146 r/	140
Bolivia (ulexite)	3	14	23	10 r/	10
Chile (ulexite)	132	97	203	117 r/	110
China e/ 3/	75	93	127 r/	100	120
Germany (borax) e/	4	3	2	2	2
Iran (borax) 4/	2	1	(5/)	1 e/	1
Kazakhstan e/	XX	XX	100	90	80
Peru	20	26	27	27 e/	27
Turkey 6/	1,250	1,210 r/	1,060	1,120 r/	1,250
U.S.S.R. e/ 7/	180	160	XX	XX	XX
United States 8/	1,090	1,240	1,010	1,060	1,110 9/
Total	2,910 r/	2,960 r/	2,670 r/	2,670 r/	2,850

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 16, 1995.

3/ B2O3 equivalent.

4/ Data are for years beginning Mar. 21 of that stated.

5/ Less than 1/2 unit.

6/ Concentrates from ore.

7/Dissolved in Dec. 1991.

8/ Minerals and compounds sold or used by producers, including both actual mine production and marketable products.

9/ Reported figure.

BROMINE

By Phyllis A. Lyday

International distribution of bromine production in 1994 was as follows: The United States, 47%; Israel, 33%; the United Kingdom, 7%; and other countries, 13%. The U.S. portion of world production has decreased steadily since 1973, when the United States produced 71% of the world supply. The decrease in world share has been a result of environmental constraints and the emergence of Israel as the world's second largest producer. Domestic capacity decreased 14% during the same period. The quantity of bromine sold or used in the United States was 195 million kilograms (kg) valued at $155 million. The value of bromine sold or used was $0.80 cents per kg. Primary uses of bromine compounds were in flame retardants (47%), agriculture (18%), water treatment and sanitizing (6%), petroleum additives (6%), well drilling fluids (5%), and other (18%).[1]

Legislation and Government Programs

The Environment Protection Agency (EPA) began its first study of organobromine (OB) chemicals in 1984, when ethylene dibromide (EDB) was the most important product of the OB industry. EDB was used with tetraethyl lead in additives designed to increase the octane rating of gasoline. Other industry products included methyl bromide, used as a soil fumigant, and brominated fluorocarbons, which were sold mainly as fire-extinguishing agents. During the decade that has elapsed, the product mix has changed, due primarily to several environmental regulatory programs. The phaseout of leaded gasoline is almost complete. The use of methyl bromides has been restricted, and two of the important fire extinguishing compounds are being phased out under the terms of the Montreal Protocol on Substances that Deplete the ozone layer, to which the United States is a signatory. Most OB chemicals are sold as flame retardants that are incorporated into polymer mixes. Smaller bromine-producing firms manage all their solid waste as hazardous and ship it off site to incinerators or landfills operating under authority of RCRA Subtitle C. Because bromine is an element and cannot be destroyed by chemical transformations, the production processes at the major facilities are designed to make the most effective use of all bromine extracted from the brine. As a result, there are many bromine recovery processes built into each operation. EPA proposed in the May 11, 1994, Federal Register to list one stream as hazardous wastes under Subtitle C of RCRA.

EPA added 286 chemicals to the Toxic Release Inventory (TRI) to bring the total added to 654 chemicals. Most of the 286 chemicals added to the TRI list are pesticides, such as alachlor, aldicarb, benomyl, bromine, carboduran, diazinon, malathion and simazine. EPA said that it may expand the scope of facilities that must report to include dealers and mining.[2] EPA did not list nine other waste streams and deferred action on one waste stream.

EPA proposed the Federal Register on January 12, 1994, to add 313 chemicals and chemical categories to the list of toxic chemicals required to be reported under section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and section 6607 of the Pollution Prevention Act of 1990. EPA believes that these chemicals and chemical categories meet the criteria of acute human health effects, carcinogenicity or other chronic human health effects, and/or their environmental effects for addition to the list of toxic chemicals. Included on the list was bromine and seven other brominated compounds. Under Section 304(b) of the Emergency Planning and Community Right-to-Know Act (EPCRA) immediate notification must be given the EPA within 15 minutes after having knowledge of the spill or leak.[3]

The Toxic Substance Control Act (TSCA) requires manufacturers and importers to report specified data on certain substances on a 4-year cycle. The Federal Register on June 14, 1994, p. 30652 reported that the period was August 25 through December 23, 1994. Reported information includes: Chemical Name and Chemical Abstracts Service (CAS) Registry number; name and address of each site at which 4,536 kg (10,000 pounds) or more is manufactured or imported; a statement of whether the substance is manufactured and processed only within the site, and the total volume (in pounds).

The EPA finalized a baseline production and consumption allowance for methyl bromide and hydrobromofluorocarbon (HBFC) (22B1-1). Methyl bromide production is frozen at 1991 levels until the fumigant is banned in 2001. HBFC production is frozen at 1991 levels until phaseout at the beginning of 1996. Great Lakes Chemical Corp. is limited to 19,945,788 kg of production and 15,414,746 kg for consumption of methyl bromide. Albemarle Corp.'s yearly baseline for production is 8,233,894 kg and consumption was 6,379,906 kg for methyl bromide. AmeriBrom Inc. baseline production is 3,524,393 kg and consumption is 4,535 kg for methyl bromide. Great Lakes is limited to 45,211 kg for production and 40,110 kg for consumption.[4] Under the Clean Air Act, methyl bromide production must be phased out by January 2001. Methyl bromide is a coproduct of tetrabromobisphenol A production. U.S. farmers used about 19,700 tons (43.5 million pounds) of methyl bromide.[5]

The Interagency Testing Committee (ITC) established under section 4(e) of TSCA revised the Priority Testing List by removing two chemicals and four chemical groups from the list for priority consideration by the EPA Administrator. The chemicals being removed included brominated flame retardants (23 chemicals). The report says that removal of these chemicals and chemical groups from the list should be interpreted only as a reordering of priorities, and not a statement that the testing recommended earlier has been completed or is not needed.[6]

The U.S. Department of Agriculture (USDA) published Agricultural Economic Report Number 877 on the "Economic Effects of Banning Methyl Bromide for Soil Fumigation." Methyl bromide has been used since the 1930's as a soil fumigant to control pests and protect stored commodities. The methyl bromide ban is limited to 21 crops produced in 5 States. The crops studied include 10 fruit and nut crops, 8 vegetable and specialty crops, and 3 miscellaneous crops. The economic effects derived were based on 1991-92 crop year estimates of available alternatives, treated acres, and production losses that could change with atypical changes in weather, pest population outbreaks, loss of available alternatives, or new nonchemical and chemical pest control strategies. An estimated 29,000 tons (64 million pounds) of methyl bromide were used in 1990 in the United States. The estimated production costs and prices effects assume that growers will use alternative chemical fumigants that cost more for some crops, and that these alternatives are generally less effective. Based on discussions with commodity experts in USDA's Economic Research Service, it was assumed that 70% of tomato, 90% of tobacco, and 15% of strawberry production losses would be replaced by imports.

A reauthorization of the Hazardous Material Transportation Act of 1990, which regulates bromine transportation, was approved by Congress and signed into law August 26. The bill contains a compromise measure that gives the Department of Transportation the discretion to decide whether to provide $1 million in grants for a study demonstrating the feasibility of establishing and operating a computerized telecommunications emergency response information system.[7]

Production

Domestic production data for bromine were developed by the U.S. Bureau of Mines from a voluntary survey of U.S. operations. Of the all operations to which a survey request was sent, six responded, representing 100% of total elemental bromine sold or used. *(See table 1 and 2.)*

Ethyl Corp. and Great Lakes produced and marketed bromine chemicals from plants in Arkansas. Small amounts of unpurified bromine were produced in Michigan as a byproduct in the extraction of magnesium from brine and reprocessed for consumption in Arkansas. The Arkansas plants accounted for 94% of U.S. elemental bromine capacity at yearend 1994 and 100% of bromine sold or used.

In February, Ethyl spun-off bromine chemicals into one of three global chemical businesses and named the new company Albemarle Corp. The name dates back to the roots of the company as Albemarle Paper founded in 1887. Albemarle's 1993 sales were $903 million including bromine chemicals, olefins, and derivatives. At the time of the spinoff, the company employed 3,800 workers in the United States, Belgium and France. In 1993, the company acquired Potasse et Produits Chimique (PPC) a maker of inorganic bromine compounds from Rhône-Poulenc S.A.[8] At PPC the main products are synthesized organobromine intermediates and organic bromine compounds. PPC's purchase boosted bromine division sales by 50%.[9] In March, Albemarle began startup of the new flame retardant facilities. The new facility at Magnolia, AR, was part of a $20 million project to add capacity in fire retardants.[10] The flame retardant is used in expandable polystyrene, foamed polystyrene, high-impact polystyrene, adhesives, and coatings.[11]

Albemarle formed a new water treatment chemical business for marketing sodium bromine. Sodium bromide 40 and 45 are registered by EPA for use as a disinfectant, fungicide, algicide, and molluscicide in water treatment. Sodium bromide 40 and 45 inhibit corrosion and are compatible with most construction materials. The products are clear, nonflammable liquids that are used in power generation facilities, refineries, industrial chemical plants, and pulp and paper mills. Bromine is three times more effective than chlorine in controlling algae in cooling towers.[12]

Great Lakes restructured into six autonomous business units during 1994. Bromine is a major raw material in five of the six.[13] Great Lakes was spending an estimated $40 million to upgrade its elemental bromine capacity domestically and in Europe. The move was tied to a related $60 million outlay in flame retardant products. The company had about 106,600 tons (235 million pounds) per year of capacity in 1992, representing 20% of the world's supply.[14]

Great Lakes and Albermerle use Bromine Recovery Unites (BRUs) to recover bromine values from organic liquid and vapor waste streams. In these units, organics are burned and the combustion products are removed by a wet scrubber. The BRUs are halogen acid furnaces (HAFs), which meet the regulatory definition of industrial furnace in 40 CFR 260.10.

The process for converting bromide brines to bromine requires that the brine be acidified and chlorinated. This reaction generates sodium chloride, which remains in the brine. Most organobromine chemicals are produced by simple one- or two-step reactions of bromine with an organic feedstock. Many of these reactions liberate hydrogen bromide gas, which is normally scrubbed by a sodium hydroxide solution, forming a sodium bromide stream that is recycled to the bromine plant. The gas is scrubbed with a lime suspension to produce calcium bromide, a salable byproduct.[15]

Consumption

SRI International estimated 1994 U.S. end uses markets for bromine as follows: Flame retardants, 47.6%; agriculture chemicals, 17.8%; other uses, 17.8%; gasoline additive, 6.0%; biocides, 6.0%; and drilling fluids 5.3%. The growth of two major brominated flame retardants was expected to grow at 5%-6% per year. U.S. bromine compound imports reached 14,000 metric tons (30.8 million pounds); exports were 25,000 tons (55 million pounds).[16]

Great Lakes completed the purchase of E.I. du Pont de Nemours & Co.'s petroleum additives business for $41 million plus purchase of inventory. Under the purchase, Octel America Inc., a wholly owned subsidiary of Great Lakes, acquired the non-TEL side of the business, which consists of numerous additives that improve the performance of fuels, lube oils, and greases. Associated Octel is a majority-owned subsidiary of Great Lakes.

Great Lakes purchased a fine chemicals subsidiary named EniChem Synthesis (Milan, Italy). The polymer additives and related specialty chemicals business was priced at about $90 million. Production is carried out in Pedrengo and Ravenna, Italy.[17]

Tetrabromobisphenol oxide (TBBA), a specialty flame retardant, was estimated to have a world capacity of 80,000 metric tons per year.[18] Albemarle increased capacity by 50% to make TBBA at Magnolia, AR. The company has increased capacity twice in the last 2 years.[19]

Water Management Inc., Electrocatalytic Inc.'s newly formed water treatment firm, will supply electrochemical bromination systems. The organization will supply on-site manufacture of bromine-based biocides for use in cooling water towers and other applications regarding biological control and disinfection.[20]

The major halons used for fire suppression are halon 1301 and 1211. In the stratosphere, these compounds change to form bromine radicals. Although the concentration of bromine in the stratosphere is low, bromine has a more significant impact on the stratospheric balance. The Armed Forces uses halon for fire extinguishment and explosion suppression in helicopters, fixed-wing aircraft, ships, maritime craft, ground armored vehicles, and other applications. Halons are used in commercial applications to protect valuable electronics, in oil and gas production, and on civilian aircraft. There is an urgency to find suitable halon replacements. Halon alternatives are nonhalocarbon substitutes that include water sprinklers, dry chemical extinguishants, carbon dioxide, misting systems, particulate aerosols, and inert gas blends. Halon replacement should have low toxicity, cleanliness, low global environmental impact, and effectiveness as a fire extinguisher. The Department of Defense plans to have the alternatives identified by October and in place by September 30, 1995.[21]

Foreign Trade

The chemical industry was in favor of the General Agreement on Tariffs & Trade (GATT) that was signed by more than 117 nations on December 15, 1993. Congress passed the GATT in December 1994, which will take effect January 1, 1995. The Uruguay Round GATT agreement concluded after 7 years of negotiations will lower chemical tariffs by an average of 30%. The agreement's intellectual property provisions include greater patent protection for products developed by American firms. GATT changes patent enforcement from 17 years from the date of issue to 20 years from the date of application. Patents issued on applications filed before June 8, 1995, will be enforceable for either 17 years form the issue date or 20 years from the filing date, whichever is longer. Companies believe that trade disputes will be more effectively settled through the World Trade Organization. Chemicals, including bromine, are the nation's largest export commodity, as more than 10 cents out of every export dollar is a product of the chemical industry.[22] [23]

Bulk purified (99.95%) bromine was reported CIF main European port at $0.53-0.55.[24] *(See tables 3 and 4.)*

World Review

China.—Joint ventures were sought in several bromine compounds plants in the Shouguang Province by Weifang Salt & Chemical Industry Group General Corp. The State-owned enterprise is the largest base for the production of salt and salt chemicals in China. Projects are to include technology and equipment. Project No. 7 is a 1,000-ton-per-year decabromodiphenol oxide project of the Shouguang Salt Industrial Co. that would consist of 6,000 tons per year of bromine from 2.26 million tons per year of salt. The products were intended for sale in China. Project No. 26 would produce lithium bromide at the Shouguang Salt Chemical Industrial Factory that presently produces sodium and ammonia bromide. Project No. 29 is with the Shouguang Chahe Saltworks and would produce 300 tons of lithium bromide as a byproduct; present production is 460,000 tons of salt, 1,500 tons of bromine, and 100 tons per year of bromate per year. The bromate has been sold on the international market. Project No. 32 is with Shouguang Chahe Saltworks and would produce hydrobromic acid as a byproduct of the present production of 460,000 tons of salt, 1,500 tons of bromine, and 100 tons of bromate per year. *(See table 6.)*

Weifang City is situated in the middle of Shandong Province and Peninsula and has been qualified by the Government of China as a "key" city with the capacity of conducting its own business with the world. The Jiaoji railway traverses the east and west and radiates in all directions. The leading industries are light-industry, textiles, electronics, machinery, chemical, and building materials. More than 400 projects introduced or run by foreign investment have been approved by the local government, with nearly 120 joint-venture, cooperative, and solely foreign-investment enterprises.[25]

The proposed potash joint venture between China and Israel was delayed when the Chinese encountered problems in obtaining credit terms. The Eisenberg group was responsible for raising the necessary finance. The 800,000 to 1 million-tons-per-year potash mine in Qinghai is expected to cost $480 million. The Qinghai potash lakes are reported to contain high concentration of bromine. The joint venture is between The Eisenberg Group (16.4%) and Dead Sea Works (DSW) (16.5%) Sinochem, and the Chinese Government and the province of Qinghai.[26]

Europe.—Members of the European Parliament have approved a proposal to ban the production and use of the fumigant methyl bromide by the year 2000. International agreements on methyl bromide call for a production freeze only.[27]

France.—France's sole producer of Potash at Mines de Potasse d'Alsac, part of State-owned chemicals group Entreprise Miniere et Chimique (EMC) operated two underground mines near Mulhouse in eastern France. During 1993, output at the Amelie Mine in Wittelshein for potash amounted to 890,000 tons of potassium oxide and 2,287 tons of bromine.[28] Mines de Potasse d'Alsace will phase out all the government operation by 2004. Marketing is through the trading subsidiary Société Commerciale de Potasse et d'Azote.[29]

Germany.—Bromine is produced from the waste bittern of potash production in Germany. German potash and salt producers Kali und Salz AG (K:S), based in Kassel, and Mitteldeutsche Kali AG (MdK), based in Sondershausen, formed Kali und Salz GmbH in 1993. The merger was seen as a means of achieving lower unit costs and increasing their competitiveness by merging the entire German potash industry under one company. The Bischofferode Mine, located in Thuringia, received a stay from closing. The 600,000-ton-per-year mine planned to operate at a much reduced level of production and guaranteed employment for the workers until the end of 1995.[30]

Bischofferode was transferred to MdK for a promised (DM1.3 billion). The joint-venture company was formed as Mitteldeutsche Kali by Kali und Salz and Treuhandanstalt. Kali und Salz will own 51% and manage the company.[31]

A temporary suspension of the merger between German potash producers MdK and K&S was obtained by French potash producer Société Commerciale de Potasse et de l'Azote (SCPA). K&S and the joint venture formed between it and MDK must withdrawn from Vienna-based marketing organization Kali-Export GmbH, before the M&S-MdK merger can proceed.

Israel.—Bromine has been produced as a byproduct from waste bitterns associated with potash production from the Dead Sea since 1957. After potash is removed in solar ponds, the waste bitterns are processed with chlorine to recover bromine. The bromine-free bitterns are then processed to recover magnesium.

The Government began efforts in 1985 to sell a share of Israeli Chemical Co. Ltd. (ICL) to offset an investment program. ICL planned to split Dead Sea Bromine (DSB) from DSW. Much of the organic and inorganic chemical activity takes place within the framework of the massive ICL, which in 1986 was composed of 28 companies with a work force of 7,000. Formal bids were accepted in 1990, but a number of Government representatives favored a public sale rather than sale to a foreign investor. In 1991, privatization terms for ICL were approved, and ultimately 25% of ICL was sold by 1993. On October 11, the Israeli government published a tender for the sale of 25% of ICL to a single investor or group of investors. Israel Corp., (IC) Tel Aviv, is buying a 24.9% share of the ICL. IC will pay $230 million for the ICL stake. The sale will be concluded in February 195. The family of Israeli businessman Shoul Eisenberg controls 50% of the IC and 50% by an offshore corporation he also controls. Another 22% will be sold in an international offering in March or April 1995.[32] The Government will continue to hold a 27.1% share after completion of the international offering.[33]

The Knesset approved the Dead Sea Mineral Rights Law Interim Amendment November 10, 1993, clearing the way for DSW to proceed with expansion projects already under way. Unlike companies in the United States, all production is exported.[34] DSB has two production plants at Sdom and Ramat Hovav.[35] DSB announced plans to implement a $500 million expansion over the next 5 years that will increase bromine production to 200,000 tons per year. Part of the expansion effort involves construction of a salt refinery at Sdom that will use solar salt to produce electrolysis-grade salt.[36] Present salt production is used to produce chlorine, which is vital to the bromine process. Another $525 million project allocates $350 million for magnesium plant and expansion of bromine compounds production. A 50-50 joint venture between Great Lakes and DSB to build a $22 million flame retardant plant at Ramat Hovav was approved by Israel's Ministerial Economic Committee. The 25,000-ton-per-year unit will come on-stream in 1996 and reach capacity by 1998. Each partner will market product separately.[37] DSB announced plans in 1994 to construct a $11.4 million bromine plant at Sdom. The plant is due on-stream by the last quarter of 1995 and is projected to increase capacity from 140,000 tons per year to 180,000 tons per year.[38] [39] DSB a subsidiary of ICL, planned to build a fine chemicals plant. A broader partnership is being considered by the parent company for the project.[40]

Japan.—At yearend 1994, Japan agreed to drop import tariffs on five brominated compounds. The tariffs on the compounds would decrease from 4.6% to zero by April 1995.

Jordan.—Jordan is the only developing country producing potash. Arab Potash Co. Ltd. (APC) and Albemarle were negotiating to form a joint-venture company to produce bromine; ownership of the company was expected to be distributed 51% and 49%, respectively. Albemarle has operations in Houston, TX, Magnolia, AR, and Orangeburg, SC, in the United States and overseas operations at Feluy, Belgium and Thann, France.[41]

APC is planning several diversification projects for the brines of the Dead Sea. The proposed projects are for the production of bromine and bromine derivatives, industrial and table salt, and magnesium oxide. Waste brines from the potash production would be used to process bromine and magnesium chloride. The diversification hopes to attract foreign participation from companies with technical and marketing knowledge. The project will be implemented by a holding company formed by a consortium of local businesses including: APC, The Jordan Investment Corp., the Social Security Corp., Jordan Phosphate Mines Co., and the Jordanian private sector.[42] The new company is called the Jordan Industrial Chemicals of the Dead Sea Minerals Co. The decision to form the company follows a memorandum of understanding with Albemarle for construction of a 50,000-ton-per-year plant. The investment in the plant would be $145 million, and the plants are to be operational by 1997.[43]

Russia.—A large deposit of bischofite was discovered in the 1960's while exploring for oil in the territory of Lower Povolzhie, Volgograd, region in middle permian strata. The bromine existed with magnesium chloride in large concentrations. A cubic meter of the bishofite brine has a concentration of 1.4 grams per cubic centimeter of bishofite contains approximately 107 kg of metallic magnesium and 6 to 9 kilograms of bromine. Geophysical drilling of 300 wells identified reserves between 150 and 500 billion cubic meters of bischofite. The deposit is estimated to contain total resources of 345 million tons of bromide salts and 160 million tons of magnesium chloride. The salt occurs between 1,200 and 1,800 meters in strata between 20 and 70 meters thick. The uniqueness of the deposit in thickness and concentration would allow for solution mining with minimum environmental detriment to the ecology. The State-owned company, Kaustic A/O, presently operating the mine and facilities produces 3,000 tons per year of bromine (99%) and 100,000 tons per year of magnesium oxide (98%). The company is seeking joint-venture investors to expand the production.[44]

The business climate for development in oil and gas has improved as a result of privatization. Before oil and gas or mineral development, the country will need to obtain new technology and improvements to the existing infrastructure. In the near term, foreign investors will face expensive and time-consuming procedures for mining and exporting mineral resources. Mining will be subject to royalties and taxes and sometimes export duties and currency conversion requirements (up to 50%). The basic framework for acquiring the legal right to use and development mineral resources are the Law on Mineral Resources (1992) and the Regulation on Procedures for licensing the Use of Mineral Resources (1992). Actual ownership of mineral resources remains with the State. Under the new Constitution ratified in 1993, Russian citizens and private domestic enterprises should eventually be able to own land and mineral resources. The distinction between common and scarce minerals is significant in terms of jurisdiction, export restriction, and the amount and apportionment of fees and royalties, there is no formal designation of which resources or common or scarce.

Under the Law of Foreign Investment, enterprises with more than 30% foreign investment, which export its own products, are fully exempt from quota limits, export duties, and licensing requirements. Since August 1993, enterprises with more than 30% foreign investment can apply to the foreign trade association for certificates for exemption from quotas and licensing.[45]

United Kingdom.—Great Lakes' affiliate, Associated Octel, was renovating and repacking a blowing out tower used for extracting bromine from seawater at the Anglesey site.[46] Octel signed a long-term agreement to supply Ethyl's requirement for lead antiknock compounds, effectively making Octel the world's only producer of tetraethyl lead (TEL). Octel also signed an agreement to supply antiknock compound to E. I. du Pont de Nemours & Co. (Dupont) for the Mexico market. Octel's three facilities in Paimboeuf, France; Bussi, Italy; and Ellsmere Port, United Kingdom, will become the only significant sources of TEL in the world. In the United States, Dupont ended TEL production at its Deepwater, NJ, plant in 1991. Dupont closed its operation in Mexico in November 1992. PPG Industries Inc., Pittsburgh, PA, closed its U.S. Beaumont, TX, facility in 1983, and Nalco Chemical Co. closed its Freeport, TX, facility in 1985. Ethyl closed a plant in Baton Rouge, LA, in 1985 and another in Pasadena, TX, in 1980.[47]

Great Lakes (U.S.) purchased Dupont's North and South American TEL petroleum additives business through Associated Octel Co. Ltd., a wholly owned subsidiary. This purchase will almost double Octel's current production of petroleum additives.

Under the Montreal Protocol, production of halons ceases at the end of this year, except those uses deemed essential by all parties to the protocol. The United Kingdom listed six uses on the list covering halons 1211 and 1301 in aircraft, airport vehicles, offshore oil and gas installations, and certain train engine rooms. The essential uses must be agreed upon by the end of 1994.[48]

Current Research and Technology

Researchers at the National Institute of Technology have recommended several chemicals as replacements for Halon 1301, a fire-fighting agent used aboard aircraft. The agent is being phased out because of its ozone-destroying properties. The U.S. Air Force is testing possible replacements and plans to install new fire-fighting agents in its fleet in 1996.[49]

Regulations and economics have increased the use of techniques to control volatile organic compounds (VOC), such as waste steams with methyl bromide. Recuperative thermal processes transfer the heat of combustion to another air stream via heat exchange. The hot air produced from the process can be used for other processes therefore lowering energy costs.[50]

Oxidation Reduction Potential (ORP) is a useful process that is often misunderstood. Typical oxides include bromine. Oxidizer chemicals have the ability to donate electrons and the greater the rate of donation, the faster is the rate of reaction.[51] Bromine can be substituted for other oxidizer to increase the rate of reaction.

An acetylene based resin shows promise for replacing thermosets such as epoxies and polyimides, especially in electronics uses. Using propargyl bromide, bisphenol A, and potassium carbonate in acetone under reflux for 3 days, a resin with good resistance to moisture at high temperature was produced. The monomer is a crystalline solid that can be purified by recrystallization and freed of metal ions.[52]

One year after the manufacture of halons was banned, teams of scientists at six European laboratories ended a 2-year project to examine a range of possible substitutes. Halon 1301 is one of two halons widely used in commercial and military applications for fire suppression. Halon 1211 is used to protect valuable electronics in oil and gas production and on civilian aircraft, and by the military in fixed-wing aircraft, helicopters, ships, and ground armored vehicles such as tanks. Fire extinguishing agents are of two types. Additive agents, operate primarily by heat absorption. Reactive agents operate by removing free radicals from flames and combustion systems. Reactive chemical inhibition is much quicker because the rates of gaseous free-radical reactions in flames are extremely fast. The fire is put out in less time with less damage to humans and property. Substitutes for halons (SUBSTHAL) inhibit by their heat capacities, not by free-radical reactions. During explosions, halon 1301 can completely extinguish the detonation dependent upon pressure and concentration of hydrogen in the mixture. The research has shown that none of the fluorinated hydrocarbons tested are as efficient at extinguishing fires as are the halogens. Compounds that were screened or assessed with in the SUBSTHAL project were less effective than halon 1301 as a fire retardant. Bromine is the optimum halogen to have in this class of compounds. The ozone depletion potential of the proposed replacement compounds are known to be either zero or significantly smaller than those of the fully halogenated chlorofluorocarbons. However, the environmental impact of the products formed when these compounds are degraded in the atmosphere has not been fully assessed.[53]

Factors such of soil pH and moisture affect how much methyl bromide escapes to the atmosphere after agricultural fields are treated with the fumigant. In field experiments, researchers measured the flux of methyl bromide into the atmosphere, the amount of the gas in the soil at varying depths, and the bromide content of the soil before and after fumigation. Less of the fumigant escapes to the atmosphere with higher soil pH, greater moisture content and organic matter in the soil, and greater injection depth.[54]

The August issue of Die Makromolekulare Chemie: Macromolecular Symposium, v. 85, pp. 1-392) published many of the key papers presented at the 11th International Symposium on Cationic Polymerization and Related Ionic Process. Bromine is used as an initiator and as an additive salt in the living polymerization reactions.[55]

Outlook

Sales of bromine, primarily in compounds, have decreased 195,000 from 226,000 kg. This represents an annual rate of decrease of about 1% per year. These decreases have been offset by increased use of bromine in fire retardants, sanitizer, and well-drilling fluids. Bromine is expected to increase in demand at (the same) rate through the next 5 years. Demand as a fire retardant will offset any decreases in other uses.

Petroleum.—Demand for bromine as a gasoline additive has declined each year since the EPA issued regulations in the 1970's to reduce the lead in gasoline. Bromine in the form of EDB is used as a "scavenger" for the lead to keep the lead from depositing in the engine. In 1979, the amount of bromine sold reached a peak of 225 million kg. The rapid decline to 141 million kg in 1986 was a direct result of the limits on lead in leaded gasoline. The EC continued discussions to reduce lead levels in gasoline.

Federal laws enacted to encourage alternative forms of power in automotive engines are likely to have a depressive effect on increases in petroleum demand. The Clean Air Act Amendments of 1990 has an amendment that will require mobile sources, such as cars and trucks, to use the most effective technology possible to control emission. Electric cars that do not require bromine gasoline additives are already on the market in California.

Sanitary Preparations.—Bromine has found usage in swimming pools, hot tubs, and whirlpools. The sanitary preparation field is an area where bromine has been found to be safer than its substitutes because bromine has a higher biocidal activity level for the same amount of product. Applications in the pulp and paper industry and in cooling towers and Government-regulated food-washing applications are growth areas. The use of bromine will continue to grow in this area, closely following the gross national product in real growth.

Fire Retardants.—Federal regulations covering flammability of private and public building materials and furnishings have required greater amounts of fire retardant chemicals to be used in these materials and furnishings. Fire retardants are expected to grow as organic materials replace metals in transportation, infrastructure, and packaging. Several State governments continue to support strong consumer laws that protect State residents from products with potential fire hazards produced in other States. Fredonia Group reported in a Flame Retardants study that demand was expected to increase by an average 5% per year to a level of $1.8 billion in 1998. Due to cost and applicability advantages, additive flame retardants demand was expected to increase faster than reactive types.[56]

Other Uses.—Usage of calcium bromide and zinc bromide in well-drilling fluids decreased during the 1980's as the domestic petroleum industry suffered a severe recession. During 1994, the number of workover rigs in the field in the United States was down 12%.[57] Oilfield chemicals used in drilling, completion and workover, and production operations have remained significantly more profitable internationally than in U.S. operations. The competition market included corrosion inhibitors, bactericides, viscosities and defoamers, as well as commodities such as calcium chloride and calcium bromide brines used to maintain well productivity.

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TABLE 1
SALIENT BROMINE AND BROMINE COMPOUND STATISTICS 1/
(Thousand kilograms unless otherwise specified)

		1990	1991	1992	1993	1994
United States:						
Bromine sold or used: 2/						
Quantity		177,000	170,000	171,000	177,000	195,000
Value	thousands	$131,000	$124,000	$125,000	$123,000	$155,000
Exports:						
Elemental bromine:						
Quantity		2,930	2,560	5,320	6,010	6,470
Value	thousands	$4,000	$7,670	$5,540	$7,440	$7,270
Bromine compounds: 3/						
Gross weight		17,100	17,100	20,000	15,800	13,700
Contained bromine		14,400	14,600	16,900	13,400	11,500
Value	thousands	$18,200	$21,300	$26,400	$21,800	$21,100
Imports: 4/						
Elemental bromine:						
Quantity		756	142	851	850	319
Value	thousands	$508	$91	$522	$513	$194
Compounds:						
Ammonium bromide:						
Gross weight		1,530	2,060	1,790	1,240	1,120
Contained bromine		1,250	1,680	1,460	1,010	917
Value	thousands	$2,400	$3,130	$2,870	$2,020	$1,850
Calcium bromide:						
Gross weight		11,600	14,600	5,370	9,650	4,510
Contained bromine		9,300	11,700	4,290	7,720	3,610
Value	thousands	$5,240	$7,130	$3,210	$3,740	$5,380
Potassium bromate:						
Gross weight		199	386	407	280	166
Contained bromine		42	185	195	134	79
Value	thousands	$615	$1,240	$1,250	$892	$538
Potassium bromide:						
Gross weight		593	888	883	1,180	1,280
Contained bromine		461	595	592	790	858
Value	thousands	$1,030	$1,590	$1,660	$2,170	$2,270
Sodium bromate:						
Gross weight		NA	229	176	290	276
Contained bromine		NA	121	93	153	146
Value	thousands	NA	$391	$469	$725	$714
Sodium bromide:						
Gross weight		1,630	3,040	1,100	1,270	1,400
Contained bromine		1,270	2,360	852	983	1,090
Value	thousands	$2,130	$3,880	$1,620	$1,730	$1,770
Other:						
Gross weight		11,600	11,600	11,700	12,500	14,300
Contained bromine		7,080	7,100	7,160	7,600	8,680
Value	thousands	$50,400	$24,600	$21,500	$36,500	$42,600
World: Production		390,000	392,000	393,000	393,000 r/	412,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, may not add to totals shown.

2/ Elemental bromine sold to nonproducers, including exports, or used in the preparation of bromine compounds by primary U.S. producers.

3/ Bureau of the Census. Includes methyl bromine and ethylene dibromide.

4/ Bureau of the Census.

TABLE 2
BROMINE-PRODUCING PLANTS IN THE UNITED STATES IN 1994

State and company	County	Plant	Production source	Elemental bromine plant capacity 1/ (million kilograms)
Arkansas:				
Arkansas Chemicals Inc.	Union	El Dorado	Well brines	23
Ethyl Corp.	Columbia	Magnolia	do.	45
Do.	do.	do.	do.	73
Great Lakes Chemical Corp.	Union	El Dorado	do.	48
Do.	do.	Marysville	do.	36
Do.	do.	El Dorado	do.	23
Michigan:				
The Dow Chemical Co.	Mason	Ludington	do.	11 2/
Total				259

1/ Actual production capacity is limited by brine availability.

2/ Bromine produced at this plant is reprocessed in Arkansas.

TABLE 3
YEAREND 1994 PRICES FOR ELEMENTAL BROMINE AND SELECTED COMPOUNDS

Product	Value per pound (cents)	Value per kilogram (cents)
Ammonium bromide, National Formulary (N.F.), granular, drums, carlots, truckloads, f.o.b. works	131	289
Bromine:		
Drums, truckloads, works 1/	123	271
Bulk, tank cars, works 1/	56 - 68	123
Bromochloromethane, drums, carloads, f.o.b. Midland, MI	127	280
Calcium bromide, bulk 2/	14	36
Ethyl bromide, technical, 98%, drums, truckloads	127	280
Ethylene dibromide, drums, carloads	95	209
Hydrobromic acid, 48%, drums, carloads, truckloads, f.o.b.	42	93
Hydrogen bromide, anhydrous, cylinders, 2,500 pounds, truckloads	475	1,047
Methyl bromide, tank cars	77	170
Potassium bromate, granular, powdered, 200-pound drums, carloads, f.o.b. works	179	395
Potassium bromide, N.F., granular, drums, carloads, f.o.b. works	110 - 112	245
Sodium bromide, technical, truckloads	70	154

1/ Delivered prices for drums and bulk shipped west of the Rocky Mountains, 1 cent per pound higher. Bulk truck prices 1 to 2 cents per pound higher for 30,000-pound minimum.

2/ Bureau of the Census. Average c.i.f. import value.

Source: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 247, No. 1, Jan. 2, 1995, pp. 26-33.

TABLE 4
U.S. IMPORTS OF OTHER BROMINE COMPOUNDS 1/

Compounds	Harmonized Schedule Code	1993 Gross weight (kilograms)	1993 Value 2/ (thousands)	1994 Gross weight (kilograms)	1994 Value 2/ (thousands)	Principal sources, 1994
Methyl bromide	2903301520	3,570	$4,400	3,300	$4,090	Israel 100%.
Chlorobromodifluormethane	2903400020	4,680	26,700	4,700	33,900	United Kingdom 45%, France 37%, Netherlands 11%, Belgium 3%, Japan 3%, Germany 1%.
Hydrobromic acid	2811195050	294	250	255	174	Israel 100%.
Dibromoethyldibromocycloxehane	2903591500	73	1,080	59	392	Germany 48%, Netherlands 38%, Belgium 8%, Slovakia 6%.
Dibromoneopentyl glycol	2905505000	88	215	188	478	Israel 100%.
Tetrabromobisphenol A	2908102500	34	41	168	207	Do.
Decabromodiphenyl oxide and octabromodiphenyl oxide	2909300700	1,910	3,800	1,760	3,340	Israel 99%, Japan 1%.
Bromoxynil 3/	NA	1,400	NA	2,820	NA	United Kingdom 100%.
Brominanine 3/	NA	412	NA	1,040	NA	Japan 100%.

NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, may not add to totals shown.

2/ Declared c.i.f. value.

3/ The Journal of Commerce Port Import/Export Reporting Service.

Source: Bureau of the Census.

TABLE 5
WORLD BROMINE ANNUAL PLANT CAPACITIES AND SOURCES 1/, DECEMBER 31, 1994

Country and company	Location	Capacity (thousand kilograms)	Source
China:			
Laizhou Bromine Works	Shandong	11,500	Underground brines.
France:			
Atochem	Port-de-Bouc	13,600	Seawater.
Mines de Potasse d'Alsace S.A.	Mulhouse	2,300	Bitterns of mined potash.
Germany:			
Kali und Salz AG: Salzdetfurth Mine	Bleichrode	2,500	Do.
India:			
Hindustan Salts Ltd.	Jaipur		
Mettur Chemicals	Mettur Dam	1,500	Seawater bitterns from salt production.
Tata Chemicals	Mithapur		
Israel:			
Dead Sea Bromine Co. Ltd.	Sodom	140,000	Bitterns of potash production from surface brines.
Italy:			
Societa Azionaria Industrial Bromo Italiana	Margherita di Savoia	900	Seawater bitterns from salt production.
Japan:			
Toyo Soda Manufacturing Co. Ltd.	Tokuyama	20,000	Seawater.
Spain:			
Derivados del Etilo S.A.	Villaricos	900	Seawater.
Russia:			
Kaustic A/O	Volgograd	3,000	Solution mining of Bischofite.
United Kingdom:			
Associated Octel Co. Ltd.	Amlwch	30,000	Do.

1/ Excludes U.S. production capacity. See table 2.

TABLE 6
BROMINE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand kilograms)

Country 3/	1990	1991	1992	1993	1994 e/
Azerbaijan e/	XX	XX	5,000	4,000	3,000
China e/	8,080	12,100	16,700 r/	18,000 r/	19,000
France e/	3,100	3,000	3,200 4/	2,290 r/	2,500
Germany e/	1,500 4/ 5/	1,500	750	750	750
India e/	1,300	1,300	1,300	1,400	1,400
Israel e/	130,000	135,000	135,000	135,000	135,000
Italy e/	400	400	300	300	300
Japan e/	15,000	15,000	15,000	15,000	15,000
Spain e/	300	300	250	200	200
Turkmenistan e/	XX	XX	12,000	10,000	8,000
U.S.S.R. e/ 6/	25,000	24,000	XX	XX	XX
Ukraine e/	XX	XX	7,000	5,000	4,000
United Kingdom	28,000 e/	29,300	29,900	27,400 r/	28,000
United States 7/	177,000	170,000	171,000	177,000	195,000
Total	390,000	392,000	397,000 r/	396,000 r/	412,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; data may not add to totals shown.

2/ Table includes data available through May 25, 1995.

3/ In addition to the countries listed, several other nations produce bromine but output data are not reported, and available general information is inadequate to formulate reliable estimates of output levels.

4/ Reported figure.

5/ Excludes Eastern States.

6/ Dissolved in Dec. 1991.

7/ Sold or used by producers.

CADMIUM

By Peter H. Kuck

Cadmium usage in secondary batteries continues to grow and now constitutes the major end use for the element. Cadmium (Cd) forms stable alloys with copper, tin, and several other nonferrous metals. When aluminum, brass, copper, and steel are coated with cadmium metal, they become much more resistant to corrosion, especially in marine and alkaline environments.

Cadmium pigments are more stable than organic coloring agents at elevated temperatures and are not easily degraded by light. Because of their excellent coloring properties, cadmium pigments are widely used in thermoplastics, ceramics, glazes, and artists' colors. Cadmium compounds are used to stabilize polyvinylchloride (PVC) and are frequently incorporated into solar cells, radiation detectors, lasers, and other electro-optical devices.

The price of cadmium metal partially recovered after falling to an all time record low of $0.451 per pound for the year 1993. Apparent U.S. demand for the metal declined substantially in the face of increasingly stringent environmental regulations and worldwide recessionary forces. The traditional markets in pigments, stabilizers, and coatings have all been contracting since the late 1980's. However, increasing amounts of cadmium have been coming into the United States in the form of nickel-cadmium (Ni-Cd) batteries.

Demand for Ni-Cd batteries has been growing worldwide because they are widely used in camcorders, laptop computers, and portable telephones. The bulk of the batteries entering the United States are made in Japan, Mexico, China, or France (in descending market share).

Most of the virgin cadmium currently being recovered is a byproduct of zinc refining. The cadmium is associated with the zinc in concentrates of sphalerite (ZnS) and related sulfide ore minerals. It is also recovered during the beneficiation and refining of some lead ores or complex copper-zinc ores.

Cadmium is considered toxic, particularly in soluble and respirable forms, and must be handled with care. Although cadmium commonly is associated with zinc, the two behave somewhat differently in biological systems.[1] Zinc is an essential element in almost all biological systems and plays important roles in metalloenzyme catalysis, metabolism, and the replication of genetic material. Cadmium, on the other hand, can adversely affect the renal and respiratory systems, depending upon exposure time and concentration, and is not readily excreted. Inhaled cadmium fumes or fine dust are much more readily absorbed than ingested cadmium. Repeated exposure to excessive levels of dust or fume can irreversibly injure the lungs, producing shortness of breath and emphysema. Dermal contact with cadmium results in negligible absorption. The International Agency for Research on Cancer (IARC) lists cadmium metal and several of its compounds as carcinogens.[2]

Legislation and Government Programs

In April 1993, the Occupational Safety and Health Administration (OSHA) revised its cadmium exposure standards.[3] [See Code of Federal Regulations (Title 29 - Parts 1910, 1915, and 1928).] Additional corrections specific to construction sites and shipyards (Parts 1915 and 1926) were published on January 3, 1994.[4] The January document also contains important background information, including the safety data sheet for cadmium, technical guidelines for handling the metal and its compounds, and recommended medical monitoring procedures.

On March 22, 1994, the Federal Circuit Court of Appeals for the Eleventh District remanded the OSHA Cadmium Standard to OSHA, indicating that the agency had not established the technological feasibility of the standard for pigments formulators or those who incorporate cadmium pigments into plastics, ceramics, glasses, and enamels.[5] The court action was taken in response to a petition filed by the Color Pigments Manufacturers Association, Inc. (CPMA) with intervention of The Cadmium Council, Inc. The court did not accept the argument that a separate health standard was required for the cadmium pigments industry. For cadmium pigments users, the action effectively reinstated the old Permissible Exposure Limit (PEL) of 100 or 200 micrograms (μg) of cadmium per cubic meter (m^3) of air. Cadmium pigments manufacturers, though, must adhere to the requirements of the new OSHA standard of 5 $\mu g/m^3$. The cadmium pigments formulators have voluntarily agreed to limit their worker exposures to 50 $\mu g/m^3$, pending a settlement with OSHA on this issue.

On September 19, 1994, the U.S. Environmental Protection Agency (EPA) set final universal treatment standards for a number of wastes containing cadmium and other hazardous metals.[6] These wastes are part of a much larger group of wastes regulated under the Resource Conservation and Recovery Act (RCRA). EPA issued the new standards to eliminate confusion about the handling, treating, and disposal of wastes of different origins. The standards apply to "listed" wastes, and not to "characteristic metal" wastes, which have separate standards. Cadmium-bearing wastes falling into the "listed" category include: Wastewater treatment sludges from electroplating operations (Waste code F006); Leachate (F039); Emission control dusts and sludges associated with the production of steel in electric arc furnaces (K061); and Emission control dusts and sludges from secondary lead smelting (K069).

On February 11, 1993, EPA proposed new streamlined regulations governing the collection and management of spent Ni-Cd batteries, mercury-containing thermostats, and certain other widely generated hazardous wastes. The agency solicited additional comments from the general public on June 20, 1994, and put the regulations (40 CFR part 273) into effect on May 11, 1995.[7] The new regulations are designed to encourage environmentally-sound recycling of Ni-Cd batteries and keep them out of the municipal waste stream. No distinction is made on the basis of battery size or type of electrolyte.

The Defense Logistics Agency (DLA) continued to sell sticks and balls of cadmium metal from the National Defense Stockpile. Cadmium had been included in the stockpile since the Nation's entry into World War II. At that time, the metal was desperately needed for the protective plating of armament parts. However, in October 1992, the administration, together with the Congress, decided that the Government no longer needed the material and authorized disposal of the entire 2,871 metric tons (mt) in inventory. The ongoing sales are part of a much larger downsizing of the stockpile approved under the Defense Authorization Act of 1992 (Public Law 102-484).

DLA began offering the cadmium on March 22, 1993. Many of the bids during the initial 6 months were extremely low and often rejected. The first few sales drew criticism from producers and The Cadmium Council because bids were accepted in the \$0.18 to \$0.25 per pound range.[8] The unit prices being bid improved considerably during the second half of 1993, with some material being awarded at \$0.43 per pound.

By the beginning of 1994, uncommitted stocks had shrunk to 5,884,710 pounds (2,669 mt). In early 1994, Congress approved DLA's request to raise the fiscal year sales limit from 500,000 pounds to 750,000 pounds. An additional 459,926 pounds (209 mt) were turned over to purchasers in 1994, leaving uncommitted stocks of 5,250,135 pounds (2,381 mt) on December 31. Total yearend stocks also included 210,060 pounds (95 mt) of committed material.

Production

Primary cadmium was produced by only two companies: Big River Zinc Corp., Sauget, IL; and Savage River Zinc Co., Clarksville, TN. Both companies recovered cadmium as a byproduct of smelting domestic and imported zinc concentrates. The cadmium recovery facilities of ASARCO Incorporated, Denver, CO; and Zinc Corporation of America, Bartlesville, OK, were idle the entire year.

In spring 1994, Savage Resources Ltd. of Australia completed its acquisition of Jersey Minière. The acquisition was part of a broader transaction involving all the zinc mining and processing operations controlled in the United States by the giant Union Minière Group. On December 31, 1993, Savage River bought a 30% interest in Union Mines Inc., the parent of Jersey Minière. Union Minière sold the remaining 70% to the Australians 3 months later. The sale included both the Clarksville refinery and Jersey Minière's four zinc mines, which are also in Tennessee.

Domestic production data for cadmium metal and compounds are developed by the U.S. Bureau of Mines (USBM) from a voluntary survey of U.S. operations. All four present or recent producers responded to the Bureau's 1994 survey requests.

Since 1993, the International Metals Reclamation Co., Inc. (INMETCO) has been recovering test quantities of cadmium metal at its metals recovery facility in Ellwood City, PA. The facility was set up in 1978 to reclaim chromium and nickel from emission control dusts, swarf, grindings, and mill scale—all generated by the stainless steel industry. The plant later was modified to process filter cakes, plating solutions and sludges, spent Ni-Cd batteries, and a variety of other recyclable ferrous metal-bearing wastes. In 1993, INMETCO produced 22,196 mt of chromium-nickel-iron alloy from 58,000 mt of solid waste and 710,000 gallons of liquid waste. The 58,000 mt of solids included 1,900 mt of spent consumer and industrial Ni-Cd batteries.[9]

INMETCO processed even more batteries in 1994—2,417 mt with an average Cd content of 15%—generating 363 mt of secondary cadmium. The company reclaimed a similar amount of cadmium in 1994 from electric arc furnace dusts and plating sludges. Prior to 1995, the cadmium from the batteries and other wastes was recovered as a baghouse dust and shipped offsite for further processing.

In May 1994, INMETCO acquired key cadmium recovery technology from Saft Nife AB. That same month, INMETCO awarded a contract to design and construct a full-scale cadmium recovery unit at Ellwood City. This unit was to be commissioned in late 1995.

Consumption

Apparent consumption of cadmium metal in the United States dropped 65% between 1993 and 1994. (See table 3.) The USBM does not collect actual consumption data on either cadmium metal or cadmium compounds. However, the International Cadmium Association does make annual estimates on an end use basis for the Western World. Their breakdown for 1994 was as follows: batteries, 65%; pigments, 15%; stabilizers for plastics and similar synthetic products, 10%; coatings and plating, 10%; and alloys and miscellaneous, 2%.[10]

A significant shift in the cadmium demand pattern has occurred over the last 10 years. Demand for Ni-Cd batteries has grown, while markets for other key cadmium-based products have shrunk. The markets for pigments, stabilizers, and coatings have declined steadily since 1991 when the European Union (EU) began tightening restrictions on cadmium-based products.

The incineration of plastics containing cadmium pigments and stabilizers is of greater concern in Western Europe than in the United States. Landfilling, which locks up the cadmium, is not a viable option in the Benelux countries and other parts of Europe where the population density is extremely high and geologically secure sites are limited.

New health and safety regulations in both the EU and the United States have discouraged sales of cadmium-based products to the heat stabilizer market. On January 1, 1994, Witco Corp. voluntarily stopped selling cadmium-based *solid* heat stabilizers for flexible PVC.[11] The Greenwich, CT based company also has begun phasing out sales of cadmium-based *liquid* heat stabilizers. A spokesperson for Witco said that the action was taken because of increasing regulatory pressures, negative publicity over heavy metals, and company concerns over the ultimate disposal of PVC. Witco has been encouraging its customers to switch to either barium-zinc or calcium-zinc heat stabilizers.

At least two competitors, Cookson America, Inc. and Akcros Chemicals v.o.f., have decided to continue selling cadmium-based stabilizers as long as sufficient demand exists. Both are U.S. ventures of large European chemical companies.[12]

The colorant and pigment industry has restructured almost every aspect of production in response to various new government regulations. In past years, the industry relied heavily on chromium and lead as well as cadmium. Today, the United States has fewer pigment producers and is more import dependent. The regulations also have encouraged replacement of the traditional heavy metal pigments by less attractive substitutes.

Both Engelhard Corp. and SCM Corp. have remained in the market and continue to produce cadmium sulfide. Several other companies, though, have reduced or completely phased out manufacturing of heavy metal colorants. Ciba-Geigy Corp. is a good example. The Ardsley, NY based specialty chemical producer controls about 20% of the colorant market on a dollar basis, but has not produced any heavy metal-based pigments since the 1980's.[13]

Automobile manufacturers have cut back on the use of cadmium-based pigments in car interiors. This action was taken in response to recent European restrictions. U.S. automobile manufacturers are trying to avoid producing different versions of vehicles for Europe and North America.

Replacement of key cadmium pigments by organic substitutes is not that straightforward, especially for applications that require high temperature or pressure processing. Organic substitutes are not as stable and are more difficult to work with under these conditions. In other applications, more organic pigment is needed to duplicate the color effect produced by the cadmium, driving up costs. Further substitution is becoming increasingly difficult. The alternatives still cannot match many of the properties of cadmium pigments (e.g., color brightness, opacity, heat and light stability, processability, etc.) that have made them popular for decades.

Ferro Corp. of Cleveland, OH, and Rhone-Poulenc Chimie of Paris, France were considering forming a joint venture to manufacture and market a line of cerium sulfide (Ce_2S_3) pigments.[14] Cerous (III) sulfide is red in color and appears to be a suitable alternative to some of the cadmium-based red pigments currently used in plastics. Several ceric (IV) salts are red-orange to yellow and conceivably could be formulated into substitute pigments. The cost competitiveness of the new substitutes still needs to be determined.

Wolverine Plating Corp. and several other plating companies in the Detroit area have stopped using cadmium and switched over entirely to zinc. The automotive industry, one of their larger customers, has dropped all of its requirements for cadmium plating because of new restrictions on the use of cadmium coatings in the EU. Most cadmium electroplaters in the United States now operate well below the OSHA action limit of 2.5 $\mu g/m^3$ and have not had to stop plating because of the new OSHA standard. (There have been a few exceptions—primarily companies involved in mechanical plating.)[15]

Cadmium plating is still required for applications where the surface characteristics of the coating are critical (e.g., fasteners for aircraft, electrical connectors, parachute buckles.) Cadmium coatings do not oxidize as readily as zinc coatings in marine or concentrated salt atmospheres and have lower relative coefficients of friction, making for smoother surfaces.

Prices

Cadmium prices began rising dramatically at the beginning of 1994 and did not level off until October. The New York dealer price for metal, published by *Metals Week* for the week ending January 7, 1994, ranged from $0.40 to $0.50 per pound, in line with the 1993 average of $0.451 cents.

Prices were extremely depressed in 1993 and had been falling since 1989, when the average annual price for metal was $6.28 per pound. An all time historic low of $0.38 to $0.48 was reached on June 10, 1993. The low prices had a discouraging effect on recycling. Analysts attributed the depressed prices to a variety of causes, including the global economic slowdown, loss of markets due to environmental concerns, and the introduction of stricter Federal occupational exposure standards in 1992.

The economic outlook for cadmium changed in 1994. By the end of the first quarter, the quotation had recovered to $0.70 to $0.80 per pound and was still rising. The New York dealer price continued to climb throughout the summer and eventually reached $2.00 to $2.50 on September 29. The $2.00 to $2.50 price remained in effect until December 1. At this point, the price took a downturn and kept steadily slipping until it finally leveled off at $1.60 to $1.80 on March 30, 1995. Some analysts attributed the volatility to cutbacks in primary zinc production during 1993 and a subsequent short-term run on cadmium inventories by speculators and Ni-Cd battery manufacturers. The average annual price for 1994 was $1.131.

Foreign Trade

Exports of cadmium metal and other cadmium products began to pick up in the second half of 1994, after falling dramatically in 1993. The bulk of the material went to China and Hong Kong.

Imports of cadmium metal have traditionally exceeded exports. This did not happen in 1994. Imports weakened and were down 22% from the previous year. The principal supplying countries, in descending order of receipts, were Canada, Belgium, Germany, and Bulgaria. Shipments from Mexico were down 95%. (See tables 5 and 6.)

World Review

Industry Structure.—World refinery production of cadmium was estimated at 18,100 mt in 1994. Japan was by far the largest producer of refined cadmium products, followed by Canada and Belgium. (See table 7.)

Capacity.—World cadmium refining capacity for 1994 was estimated at 23,000 mt.

International Cadmium Association.—The European and North American cadmium associations merged to form the International Cadmium Association (ICdA). The Cadmium Council, Inc. in Reston, VA, is now both the North American office of the new association and the Ni-Cd Electric Vehicle Information Center. The headquarters of the Cadmium Association in London, England, became the European office of the new organization.

European Union.—In May 1994, an EU regulation took effect that severely limits the international transport of hazardous waste and related products. The regulation was issued under terms agreed upon by much of the world in the Basel Convention. The Convention goal was to strictly control exports of hazardous wastes to Third World countries that have limited waste management capabilities.

However, European refining and recycling companies, like Union Minière, were concerned because the complex legislation makes no distinction between materials being shipped for recycling and those being sent to a disposal site. The regulation has had a major impact on some of Union Minière's plants that rely on intermediate products and industrial residues for feedstocks.[16] Union Minière operates two zinc refineries with a combined capacity of 450,000 mt of zinc per year. The two refineries—one at Balen in Belgium and the other at Auby in France—produce cadmium and sulfuric acid as byproducts.

Hydrometal S.A. of Belgium has expressed similar concerns about the EU regulation. The Belgian company has a recycling plant at Liège that treats 1,000 to 1,500 mt per month of metal-bearing oxidic residues from the rest of Europe and the United States. Hydrometal claims that the regulation is making it increasingly difficult and more expensive to obtain secondary feed materials. The company uses a hydrometallurgical process to separate cadmium, cobalt, copper, lead, nickel, tin, zinc, and precious metals from one another. The cadmium is sold as sponge; the nickel, as a carbonate; and the zinc, as a sulfate.[17]

Mexico.— In November 1994, Matsushita Battery Industrial Co. of Japan announced that it had established a subsidiary in Tijuana to manufacture small-size Ni-Cd batteries. The new company, Matsushita Battery Industrial de Baja California SA de CV, reportedly began packing operations in April 1995. The Tijuana plant is expected to produce 16 million units in 1996 and expand to 31 million in 1997. Matsushita launched similar operations in Belgium and Indonesia in 1993.[18]

Current Research and Technology

Recent developments in Ni-Cd battery technology were reviewed at an international conference on September 19-20, 1994, in Geneva, Switzerland. The conference—*NiCad94*— was organized by the International Cadmium Association with the cooperation and support of Eurobat. Four of the 27 papers presented discussed large-scale field testing of electric vehicles in Europe. Another eight dealt with the collection and recycling of spent batteries in both Europe and North America.

The nickel-cadmium, nickel-metal hydride, lithium-ion, and improved lead-acid electrochemical systems are in strong competition with one another for the portable rechargeable battery market. Improvements are continually being made to each of the systems. Energy density, cycle life, charge retention, shelf life, and performance at extreme temperatures are all being enhanced. These enhancements are being carried over into the emerging electric vehicle battery market—a market some analysts believe will be worth $300 million by the year 2000.

France, Germany, Japan, and the United States continue to be the principal manufacturers and users of Ni-Cd batteries. However, tremendous strides have been made by competitors in China and Hong Kong since 1990. China now has nine Ni-Cd battery manufacturing operations. Another four Chinese suppliers produce Ni-Cd batteries as a sideline of their zinc-manganese dry cell operations.[19]

In France, the La Rochelle electric vehicle experiment is now in its sixth year of testing. The tests are a joint project of the city of La Rochelle, the automobile manufacturer PSA Peugeot Citroën, and the electric utility Electricité de France (EDF). Fifty electric vehicles (EV's) are currently operating in the city. Forty-six of the 50 EV's are powered by Ni-Cd systems; 4 by lead-acid.[20]

German automobile manufacturers have been conducting similar field tests in Zurich, Switzerland, and on the island of Rügen in the Baltic Sea. The 4-year project began in 1992 and is run by Deutsche AutomobilgesellschaftmbH (DAUG) with the support of the German Federal Ministry for Research and Technology. Of the 59 vehicles being tested, 23 have sealed Ni-Cd batteries developed by DAUG. The DAUG battery minimizes gas pressures within the cell by using split negative, cadmium electrodes. Because of the unique electrode design, oxygen evolution is automatically controlled. The near-zero gas pressure allows the battery to be sealed and made maintenance-free. DAUG and Accumulatorenwerke HOPPECKE have formed a joint venture to manufacture the advanced Ni-Cd battery.[21]

The U.S. Department of Agriculture has been investigating a variety of plant species that preferentially concentrate mobile cadmium, nickel, and zinc from the soil by selectively absorbing the metals through their roots. A large part of the research was conducted at the Beltsville Agricultural Center in Maryland. Some of the work also was carried out by coinvestigators at Sheffield University and the University of Maryland. The team of scientists are trying to develop hybrids of these natural "hyperaccumulators" that have enhanced concentrating abilities. The hybrids would be planted across large tracts of land that have been contaminated with heavy metals and cannot be fully utilized in the present condition. The hyperaccumulators would be harvested over several growing seasons and ashed to produce a heavy metal concentrate.[22] Recent advances in genetic engineering have renewed interest in this idea of biological mining/land remediation.

In 1993, the International Agency for Research on Cancer reviewed a number of studies on the toxicological, carcinogenic, and mutagenic effects of cadmium as part of a much broader evaluation of carcinogenic risks in different occupational settings. The results of the evaluation were published in a monograph together with detailed background information on cadmium. The monograph pulls together the views and expert opinions of an IARC working group that met in Lyon, France, on February 9-16, 1993.

The working group concluded that cadmium and cadmium compounds are carcinogenic to humans. Most of the occupational exposure comes from airborne dust and fume. One of the principal hygienic concerns is the generation of cadmium oxide fumes at high temperatures, and the subsequent deposition and absorption of the oxide in the lungs. Exposure to such fumes is generally associated with the refining process (i.e., operations of roasters, calciners, kilns, and retorts.) Because of recent improvements in occupational hygiene, cadmium levels of 5 to 50 $\mu g/m^3$ of air can now be achieved at most of these facilities.

Other sources of potential high exposure include plants involved in battery manufacturing, pigment manufacturing, production of stabilizers such as cadmium stearate for PVC, or cadmium alloying of copper or silver. Special precautions also need to be taken when soldering cadmium-containing alloys or welding cadmium-coated surfaces. The separate engineering control air limits (SECALs) established by the OSHA Cadmium Standard for various industrial operations are shown in table 8 of the 1993 Cadmium Annual Review.

Outlook

The outlook for cadmium is directly related to environmental and health concerns about the metal and its compounds. The domestic cadmium industry already has taken a number of steps to minimize occupational exposure and significantly reduce any adverse effects on the environment. Cadmium emissions from most processing and downstream manufacturing operations have been lowered to extremely safe levels. Many producers and first-use consumers have upgraded their facilities and are able to fully meet the new Federal standards. Most cadmium product manufacturers operating in borderline situations feel that the new OSHA SECALs will give them the time they need to achieve the desired PEL of 5 $\mu g/m^3$.

The principal problem facing the industry today is the safe and economic disposal of spent cadmium products. The cadmium industry believes that recycling programs are the most effective way to minimize the risks to public health and the environment, and is working hard to develop new recycling technology. To date, most of the work has concentrated on the processing of spent batteries, EAF dust, alloys, and electroplating sludges. The Rechargeable Battery Recycling Association has been working with a broad spectrum of manufacturers, retailers, and government agencies to improve Ni-Cd battery recycling rates and expects to have recycling networks operating in 17 States by the end of 1997. Even the cadmium pigments contained in some plastic scrap are being considered as secondary feedstocks because of rising disposal costs and increasing regulatory pressures. Disposal costs already exceed the price for virgin metal and are rapidly reaching a point where they will equal or exceed the cost of recovering the cadmium in most major waste streams.

The market for Ni-Cd batteries is expected to grow significantly over the next 5 years even if the Ni-Cd chemistry is not adopted for electric vehicles. Ni-Cd batteries will still be used in rechargeable power tools, home appliances, and other household equipment because of cost constraints. The markets for battery-powered cellular telephones, camcorders, personal computers, and related electronic equipment are all surging. Many of the newest satellites and commercial aircraft are using advanced Ni-Cd's for secondary power sources. In general, Ni-Cd batteries have a greater service life than several competitors and are less likely to be damaged by accidental overcharging.

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TABLE 1
SALIENT CADMIUM STATISTICS 1/

(Metric tons, cadmium content, unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production of metal 2/	1,680	1,680	1,620	1,090	1,010
Shipments of metal by producers 3/	1,860	1,740	2,080	1,320 r/	1,290
Exports of metal, alloys, and scrap 4/	698	448	213	38	1,450
Imports for consumption, metal	1,740	2,040	1,960	1,420	1,110
Stocks of metal, Government, yearend	2,870	2,870	2,870	2,690	2,480
Apparent consumption	2,800 r/	3,080 r/	3,330 r/	2,940 r/	1,020
Price, average per pound, New York dealer 5/	$3.38	$2.01	$0.91	$0.45	$1.13
World: Refinery production	20,200 r/	20,900 r/	19,900 r/	18,900 r/	18,100 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

3/ Includes metal consumed at producer plants.

4/ New series of Harmonized Tariff Schedule codes.

5/ Price for 1 to 5 short-ton lots of metal having a minimum purity of 99.95%.

TABLE 2
U.S. PRODUCTION OF CADMIUM COMPOUNDS 1/

(Metric tons, cadmium content)

Year	Cadmium sulfide 2/	Other cadmium compounds 3/
1993	303 r/	731
1994	342	980

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Includes cadmium lithopone and cadmium sulfoselenide.

3/ Includes oxide and plating salts (acetate, carbonate, nitrate, sulfate, etc.)

TABLE 3
SUPPLY AND APPARENT CONSUMPTION OF CADMIUM 1/

(Metric tons)

	1993	1994
Industry stocks, Jan. 1	868	582 r/
Production	1,090	1,010
Imports for consumption, metal	1,420	1,110
Shipments from Government stockpile excesses	185	209
Total supply	3,560 r/	2,910
Exports, metal 2/	38	1,450
Industry stocks, Dec. 31	582 r/	439
Consumption, apparent 3/	2,940 r/	1,020

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ New series of Harmonized Tariff Schedule codes.

3/ Total supply minus exports and yearend stocks. Excludes shipments from Government stockpile excesses.

TABLE 4
INDUSTRY STOCKS, DECEMBER 31 1/

(Metric tons)

	1993		1994	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	220 r/	W	55	W
Compound manufacturers	67 r/	282 r/	72	299
Distributors	13	(2/)	12	(2/)
Total	299 r/	282 r/	139	299

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Compound manufacturers."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

U.S. EXPORTS OF CADMIUM PRODUCTS, BY COUNTRY 1/

Country	1993		1994	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cadmium metal: 2/				
Argentina	14	$6,090	--	--
Australia	112	4,550	--	--
Canada	14,800	131,000	23,400	$213,000
China	--	--	361,000	363,000
France	2,920	25,500	170,000	83,700
Germany	402	28,300	42,400	632,000
Hong Kong	635	5,000	725,000	662,000
India	300	7,350	77,700	76,900
Israel	1,910	12,000	547	14,100
Italy	408	7,560	--	--
Japan	4,250	99,900	4,210	217,000
Korea, Republic of	--	--	523	6,440
Mexico	4,790	29,900	39,400	216,000
Netherlands	--	--	179	12,100
New Zealand	--	--	2,880	271,000
Panama	1,390	12,300	--	--
Singapore	479	2,990	--	--
Taiwan	1,640	13,100	--	--
United Kingdom	4,000	85,500	165	6,710
Total	38,000	471,000	1,450,000	2,770,000
Cadmium sulfide: (gross weight)				
Canada	24,000	13,500	107,000	56,500
Japan	6	8,620	38,800	8,000
Korea, Republic of	--	--	44,000	43,700
Other	7,440	7,650	15,100	11,200
Total	31,400	29,800	205,000	119,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes exports of cadmium in alloys, dross, flue dust, residues, and scrap.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF CADMIUM PRODUCTS, BY COUNTRY 1/

Country	1993		1994	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cadmium metal:				
Australia	2,000	$1,920	27,000	$74,700
Belgium	178,000	215,000	232,000	496,000
Bulgaria	35,000	86,400	40,700	76,700
Canada	614,000	643,000	591,000	1,150,000
China	22	1,870	24	12,500
Finland	14,000	49,300	6,000	9,970
France	15,000	11,600	5,100	7,600
Germany	51,400	95,600	118,000	71,800
Japan	7	9,190	681	22,200
Mexico	332,000	261,000	17,800	76,800
Netherlands	17,100	11,600	25,000	94,000
Norway	59,600	53,400	34,500	60,900
Peru	--	--	10,000	16,500
Russia	76,800	220,000	--	--
Spain	19,500	18,300	--	--
Sweden	218	6,920	--	--
Taiwan	1,050	3,740	--	--
Total 2/	1,410,000	1,690,000	1,110,000	2,170,000
Cadmium sulfide: (gross weight)				
Belgium	--	--	3,600	42,600
Canada	--	--	2	5,380
Japan	1,230	30,200	28,100	83,500
United Kingdom	9,530	113,000	11,800	140,000
Total	10,800	143,000	43,500	272,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The 1994 total includes 5,000 kilograms of metal imported from France, valued at $6,280, that were removed from a bonded warehouse. General imports and imports for consumption were the same in 1993.

Source: Bureau of the Census.

TABLE 7
CADMIUM: WORLD REFINERY PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Algeria	65	78	75 e/	75 e/	75
Argentina	55	49	37	34 r/ e/	35
Australia	638	1,080	1,000	951 r/	910 3/
Austria	44	19	--	--	--
Belgium	1,960	1,810	1,550	1,570 r/	1,560 3/
Brazil e/	200	200	200	200	200
Bulgaria	309	232	194 r/	266 r/	180
Canada	1,470	1,830	1,960	1,890 r/	2,130 3/
China e/	1,100	1,200	1,150 r/	1,160 r/	1,150
Finland	569	593	590	785 r/	548 3/
France	187	271	252 r/	137 r/	140
Germany:					
Eastern states	17	XX	XX	XX	XX
Western states	973	XX	XX	XX	XX
Total	990	1,050 r/	941	1,060	1,120
India	277	271 r/	313 r/	255 r/	201 3/
Italy	691	658	742	517 r/	659 3/
Japan	2,450	2,890	2,990	2,830 r/	2,630 3/
Kazakhstan e/	XX	XX	1,000	1,000	1,000
Korea, North e/	100	100	100	100	100
Korea, Republic of e/	750 r/	750 r/	750 r/	815 r/	800
Macedonia e/	XX	XX	110	100	100
Mexico	882	688	602	797	646 3/
Namibia	69	67	33	13 r/	23 3/
Netherlands	590	549	594	526	300
Norway	286	227	247	213 r/	288 3/
Peru	265	138 r/	149 r/	157 r/	160
Poland	373	364	132 r/	150 r/ e/	150
Romania e/	40	10	10	10	--
Russia e/	XX	XX	800	700	500
Serbia and Montenegro	XX	XX	8 r/	6 r/	3
South Africa, Republic of 4/	57 r/	103 r/	60 r/	70 r/ e/	65
Spain	355	344 r/	329 r/	340 r/ e/	350
Thailand	--	373	635	449 r/	500
Turkey	46	22	23	31 r/	22
U.S.S.R. e/ 5/	2,800	2,500	XX	XX	XX
Ukraine e/	XX	XX	200	120 r/	90
United Kingdom 6/	438	449	383	458 r/	470 3/
United States 6/	1,680	1,680	1,620	1,090	1,010 3/
Yugoslavia 7/	362	250 r/ e/	XX	XX	XX
Zaire	127	65	84	12 r/	1
Total	20,200 r/	20,900 r/	19,900 r/	18,900	18,100

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ This table gives unwrought production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not; where known, this has been indicated by a footnote. Data derived in part from World Metal Statistics (published by World Bureau of Metal Statistics, Ware, the United Kingdom) and from Metal Statistics (published by Metallgesellschaft AG, Frankfurt, am Main, Germany, and World Bureau of Metal Statistics, Ware, the United Kingdom). Cadmium is found in ores, concentrates, and/or flue dusts in several other countries, but these materials are exported for treatment elsewhere to recover cadmium metal; therefore, such output is not reported in this table to avoid double counting. This table includes data available through Aug. 16, 1995.

3/ Reported figure.

4/ Cadmium content of cadmium cake.

5/ Dissolved in Dec. 1991.

6/ Includes secondary.

7/ Dissolved in Apr. 1992.

CEMENT

By Cheryl Solomon

The industry's main product, portland cement, makes up 95% of the total domestic production. The remainder comes from masonry, hydraulic, and aluminous cements.

In 1994, U.S. demand for cement increased by approximately 7%. Domestic production of portland cement increased by 5%. Cement imported for consumption increased to 11.3 million metric tons. Portland cement values increased to approximately $61 per metric ton.

Legislation and Government Programs

At the beginning of the year, the Environmental Protection Agency announced the availability of the agency's Report to Congress on Cement Kiln Dust. The Report to Congress contained a detailed study of cement kiln dust which fell within the scope of the exemption from hazardous waste regulations provided by the Bevill Exemption. The report presented the Agency's decision making rationale and a series of options being considered regarding regulatory options for cement kiln dust waste.

Production

Domestic production and consumption data for cement are developed by means of the portland and masonry cement voluntary survey. Of the 120 cement manufacturing plants to which an annual survey collection request was made, 115 responded, representing 95% of the cement production and consumption data shown in table 1. Estimates were made for nonrespondents using monthly survey data and data received from previous annual surveys. *(See table 1.)*

One State agency and 45 companies operated 118 plants in 37 States. In addition, two companies operated two plants in Puerto Rico, manufacturing hydraulic cement. The production data obtained are listed by State or groups of States that form cement districts. A cement district may represent a group of States or a portion of a State. The States of California, Illinois, New York, Pennsylvania, and Texas are divided to provide more definitive marketing information within those States, as follows:

California, Northern.—Points north and west of the northern borders of San Luis Obispo and Kern Counties and the western borders of Inyo and Mono Counties.

California, Southern.—All other counties in California.

Chicago, Metropolitan.—The Illinois counties of Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will.

Illinois.—All other counties in Illinois.

New York, Western.—All counties west of a dividing line following the eastern boundaries of Broome, Chenango, Lewis, Madison, Oneida, and St. Lawrence Counties.

New York, Eastern.—All counties east of the aforementioned dividing line, except Metropolitan New York.

New York, Metropolitan.—The five counties of New York City (Bronx, Kings, New York, Queens, and Richmond) plus Nassau, Rockland, Suffolk, and Westchester Counties.

Pennsylvania, Eastern.—All counties east of the eastern boundaries of Centre, Clinton, Franklin, Huntingdon, and Potter Counties.

Pennsylvania, Western.—All other counties in Pennsylvania.

Texas, Northern.—All counties north of a dividing line following the northern borders of Burnet, Crockett, Jasper, Jeff Davis, Llano, Madison, Mason, Menard, Milam, Newton, Pecos, Polk, Robertson, San Jacinto, Schleicher, Tyler, Walker, and Williamson Counties.

Texas, Southern.—All counties south of the aforementioned dividing line.

Clinker Production.—Clinker production in the United States, excluding Puerto Rico, increased by 4% to 68.5 million metric tons. California led all States in clinker production, followed by Texas, Pennsylvania, Missouri, and Michigan.

By yearend, multiplant operations were being run by 18 companies. The size of individual companies, as a percentage of total U.S. clinker production capacity, ranged from 0.4% to 12.7%. The 5 largest companies with clinker capacity provided about 40% of total clinker capacity; the 10 largest companies with clinker capacity provided a combined 63%. The 10 largest companies, in decreasing order of size of clinker production, were Holnam Inc.; Lafarge Corp.; Essroc Materials Inc.; Southdown Inc.; Ash Grove Cement Co.; Blue Circle Inc.; Lone Star Industries Inc.; Lehigh Portland Cement Co.; California Portland Cement; and RC Cement.

Portland Cement.—Portland cement production, excluding Puerto Rico, increased by 5% to 74.3 million metric tons.

The industry operated 118 plants, including 8 grinding facilities, to produce various types of finished hydraulic cement.

The size of individual companies, as a percentage of total U.S. finished cement production capacity, ranged from 0.4% to 12.7%. The top 10 producing companies, in declining order of production, were Holnam Inc.; Lafarge Corp.; Essroc Materials, Inc., Southdown Inc.; Ash Grove Cement Co.; Blue Circle Inc.; Lone Star Industries, Inc.; Lehigh Portland Cement Co.; California Portland; and RC Cement Co., Inc.

Masonry Cement.—Production of masonry cement increased by 22% to 3.6 million metric tons. At yearend, 84 plants were manufacturing masonry cement in the United States.

Aluminous Cement.—Aluminous cement continued to be produced by Lehigh, Buffington, IN; Lafarge, Chesapeake, VA; and Aluminum Co. of America, Bauxite, AR.

Fuel Consumption.—Approximately 71% of all U.S. clinker was produced by the dry process method. Fuels consumed in making cement with both the wet and dry process included coal, 10.5 million metric tons; natural gas, 650.1 million cubic feet; and oil, 48.8 million liters. In addition, 120,000 metric tons of tires, 74,000 metric tons of solid waste fuel, and 600 million liters of liquid waste fuel were consumed in the cement kilns.

Corporate Changes.—Florida Crushed

Stone sought permits for a new kiln to be built at its Brooksfield, FL, plant.[2] Florida Rock Industries announced plans to build a new cement plant in western Alachua County, FL. The site contained about 75 years of limerock reserves.[3] Holnam Inc. sold its Tijeras, NM, cement plant to Grupo Cementos de Chihuahua, S.A. de C.V.[4] Holderbank Financiere Glarus A.G. agreed to acquire 84.1% of the share capital of Ciments et Engraise de Dannes et de l'Est, ore Cedest, France's fifth largest cement producer.[5] Lafarge Corp. sold its New Braunfels, TX, cement plant, related cement terminals and an interest in Parker Lafarge Inc., a construction materials company based in Houston, TX, to Sunbelt Acquisitions, Inc., a U.S. subsidiary of Cementos Mexicanos, S.A. (Cemex). The purchase price for all of the assets was approximately US $100 million.[6] Lafarge Coppee sold 20% stake in Vencemos Pertigalete of Venezuela to Mexico's Cemex.[7]

Lone Star Industries Inc. appeared to have successfully emerged from the threat of bankruptcy since filing for Chapter 11 protection in December 1990.[8] Through the sale of assets, Lone Star was considerably downsized and reorganized. Lone Star Industries sold its Medley, FL, cement plant to Tarmac America Inc., which had operated the plant under lease since 1988.[9] Lone Star Industries' subsidiary, Rosebud Holdings Inc., sold its interest in a Santa Cruz California cement plant to California Readymix, Inc., a wholly owned subsidiary of RMC Lonestar. Lone Star Industries also sold its Nazareth plant to Essroc Materials Inc.[10] Rosebud Holdings also sold its Texas cement terminals to Gulf Coast Portland Cement Co.[11]

National Portland Cement Co. of Palmetto, FL, was purchased by Vencemos, Venezuela's largest cement company. Vencemos was purchased just prior by Cemex of Mexico.[12]

Lafarge Corp. sold its 12,000 ton capacity terminal in Amarillo, TX, to Southdown, Inc.[13] The terminal was to receive cement from the Southdown Odessa plant in Texas.

Southdown, Inc., announced that it was planning to leave the environmental services business. The company planned to sell its three hazardous waste processing facilities and to end the burning of hazardous waste in its cement kilns by the end of 1995.[14]

Tarmac Plc in Woverhampton, England, relocated its Tarmac America headquarters to Norfolk, VA. The company's product lines were established into three groups—aggregates and cement, ready-mix concrete, and concrete products.[15]

Consumption

Consumer demand for cement in the United States, excluding Puerto Rico, increased by 7%. According to U.S. Department of Commerce (DOC) data, housing starts increased 13% to 1.5 million units, in 1994. The value of new construction increased 9% to $507 billion. The value of residential construction increased 13% to $238 billion, primarily in single-unit structures. The value of nonresidential construction increased 9% to $97.8 billion, owing to increases in commercial building construction other than hospitals and other institutions, and hotels and motels. Public construction increased only slightly to $52 billion, with highways and streets, sewer and other public construction experienced small upward movements in spending. Military facility construction declined by 5%.[16]

California continued to lead all States in the amount of portland cement consumed, followed by, in order of shipments received, Texas, Florida, Illinois, Ohio, and Pennsylvania. Together, these States consumed 38% of the total U.S. tonnage.

On a regional basis, all nine of the Census districts experienced increases in consumption. The largest increases were experienced by the West North Central, East North Central (shown as Midwest, West, and East in table 12), New England and South Atlantic districts with increases, respectively, of 15.7%, 8.4%, 8.3%, and 7.2%. The East South Central, Pacific, and Middle Atlantic districts showed increases in consumption of 7.1%, 6.9%, and 6.4%. The West South Central and Mountain districts had the smallest increases in consumption with 4.7% and 3.4%, respectively. Particularly in the Mountain district, States such as Colorado and Montana had experienced very high levels of consumption in prior years, and therefore, actually had decreases in consumption, compared with 1993, of 16% and 31%, respectively.

Shipments of domestically produced portland cement from U.S. mills increased by 6%, while masonry cement shipments climbed 13%. *(See table 11.)* Cement shipments that were not reported to the U.S. Bureau of Mines (USBM) according to the type of customers are shown under Government and Miscellaneous *(See table 13.)* Of the cement shipments that were reported by type of customer, ready-mix concrete producers were the primary consumers of cement, accounting for about 56% of the total, followed by concrete product manufacturers, 11%; building material dealers, 5%; roadpaving contractors, 2%; and other contractors, including those that were unspecified contractors, 4%. Smaller amounts were consumed by Federal, State, and other government agencies, and by a variety of uses, such as waste stabilization and mining.

Prices

The average mill value of portland cement was approximately $61.07 per metric ton and the value of masonry cement was $79.40 per metric ton. The average value of cement by yearend reported by Engineering News Record (ENR), was $ 74.31 per metric ton. The ENR prices are based on an average per-ton value of cement delivered to 20 cities. The average price change for portland cement for December 1994 increased by 6.3% compared with December 1993.[17]

Foreign Trade

The European Commission found more than 33 European cement companies guilty of participating in an illegal price fixing cartel said to have operated in 15 countries. Italcementi SpA of Italy received the highest penalty followed by Ciments Francais and Lafarge Coppee of France.[18]

The U.S. International Trade Commission (ITC) ruled that imports of calcium aluminate cement and cement clinker from France did not injure industries in the United States. The decision meant that no antidumping duties would be imposed in this case. The original petition was filed by the Lehigh Portland Cement Co. of Allentown, PA.[19]

The ITC conducted an administrative review of the antidumping duty order on gray portland cement and clinker from Japan. The review covered one manufacturer, Onoda Cement Co., Ltd. and the period May 1, 1992 through April 30, 1993. The review indicated the existence of dumping margins during this period. As a result of the review, the Department preliminarily determined to assess antidumping duties equal to the difference between the United States price and the foreign market value.[20]

At the beginning of 1993, the International Trade Administration received a request from the Ad Hoc Committee of Florida Producers of Gray Portland Cement to conduct an administrative review of the suspension agreement on gray portland cement and clinker from Venezuela. Then at the beginning of 1994, the petitioners withdrew their request for administrative review. Accordingly, the Department terminated this administrative review.[21]

The DOC conducted an administrative review of the antidumping duty order on gray portland cement and clinker from Mexico. The review covered exports of the cement during the period August 1, 1992 through July 31, 1993, and one firm, Cemex, S.A. The results of this review indicated dumping margins for the period. On August 3, 1992, the DOC had published a notice of Opportunity to Request Administrative Review for the above time period. The petitioners, the Ad Hoc Committee of Arizona-New Mexico-Texas-Florida Producers of Gray Portland Cement and the National Cement Co. of California, Inc., requested the review. On September 30, 1993, the Department published a notice of "Initiation of Antidumping Review" for Cemex. In June 1994, interested parties were requested to comment on the results.[22]

The DOC notified the public of its revocation of the antidumping finding on portland cement from the Dominican Republic because it was no longer of any interest to domestic interested parties. The Department served written notice of its intent to revoke this antidumping finding on each domestic interested party on the service list.[23]

Exports of hydraulic cement and clinker, as reported by the Bureau of the Census, increased 1% to 633,000 metric tons. Canada received 2% of the total.

New York led all States in the amount of imports received, with 14% of total U.S. imports, or 1,526,000 metric tons. Of this total, 35% was shipped through the Buffalo Customs District, 39% was shipped through the New York City Customs District, and 26% was shipped through the Ogdensburg Customs District. These imports comprised 65% of New York's portland cement consumption compared with total imports representing 13% of apparent consumption nationally. Sixty-two percent of imports into New York came from Canada, 19% came from Greece, 14% came from Spain, and 5% from Norway. Michigan was the second largest recipient of imported cement, receiving 1.17 million tons or 10% of the total. All of the Michigan imports were shipped through the Detroit Customs District, and virtually all came from Canada.

Chinese cement entered the United States mainly through the Columbia Snake River, 77%, through Anchorage, AL, 18% and less, through the port of Seattle, 0.5%. By yearend, the Chinese had exported 317,000 tons.

World Review

World cement production increased by 5% to 1.37 billion tons. China continued to lead all nations with 29% of production, followed by Japan with 7%, and the United States with 6%.

The year saw major purchases and plans to build new cement plants by Holderbank of Switzerland, Lafarge Coppee of France, and Cemex of Mexico, among others, as shown below.

China.—U.S. Dominion Bridge Inc. of Lachine announced plans to build a massive cement plant, in conjunction with Chongqing Cement Plant Co., a state-owned corporation. The plant was to be erected 13 kilometers from Chongqing in Sichuan province, China's largest province with a population of 110 million.[24] Lafarge planned to set up a cement plant in Beijing with a joint-venture project. The investment was expected to total $130 million.[25]

France.— Holderbank acquired the majority of the shares of Cedest in a major move to reinforce its position in Western Europe. Cedest was France's fifth largest cement producer with two plants, one at Dannes and one at Heming. The company had a total annual production capacity of 2.7 million tons per year.[26]

Gaza.— A consortium of Palestinian investors was established to set up a new company, the Arab Cement Company, in order to build a cement plant in Gaza, the West Bank. The cement plant was to have a capacity of 1 million tons per year. The project was to be implemented in three stages: initial import, packaging and marketing venture, and construction of a clinker grinding plant and installation of a full-scale cement plant. The project could range from $50 to $150 million depending on where the equipment was sourced.[27]

Indonesia.— Blue Circle Industries sold its 23% share in PT Semen Andalas, Indonesia, to the Swiss-based Cementia, owned by Lafarge Coppee of France. The purchase was thought to be for about $6 million. Semen Andalas operated a 1 million ton factory on the western tip of Sumatra, Indonesia, and the accompanying port terminal. In addition to serving the domestic market in Sumatra the plant exported cement to Sri Lanka, Bangladesh, and Singapore. This purchase marked the expansion of Lafarge into a new area of the world.[28]

Israel.—Cement consumption was approximately 4.86 million metric tons, about the same amount as production. Cement production was up from 4.46 million metric tons in 1993, when cement was imported from eastern Mediterranean countries in order to fill the demand. Nesher Cement was the sole cement producer, having three plants with 4.5 million metric tons of clinker capacity and more than 5.6 million tons of clinker grinding capacity.[29]

Japan.—The Sumitomo Cement Co. and Osaka Cement Co. were to merge to form the second largest cement company in Japan. The company was to be called Sumitomo Osaka Cement Co.[30]

Mexico.—Cementos Mexicanos, among the top five largest cement companies in the world, purchased Cementos Bayano in Panama City for 60 million, and four facilities in Venezuela.[31] The purchase was part of Cemex's strategy to increase its market from Venezuela, through Panama, and Mexico, to the Carribean and to Spain. The company also purchased the former Lafarge New Braunfels plant (See Corporate Changes).

Philippines.—Cement sales in the Philippines were 12% greater in 1994 than in 1993 and were expected to surge upwards due to the country's recovering economy and emphasis on infrastructure development.[32]

Singapore.— Singapore had no fully integrated production facilities but operated five grinding facilities. Jurong Cement was the largest company with 1 million tons per annum capacity, while SsangYong Cement and Malaysia Cement had .9 million tons per annum each, and Asia Cement and

Indocement had .5 million tons per annum.[33] Cement consumption, moved up steadily from 2.83 million tons in 1991 through a high of 3.74 million tons in 1993. The total cement consumption was thought to have dropped back to 3.3 million tons in 1994.

National Cement completed the first phase of a major cement terminal at Jurong Port. The facility was to comprise a 28,000 ton silo complete with a newly designed ship unloader. The facility was formerly a grain silo and was purchased in 1993 by a group made up of Queensland Cement, Australia, Partek, Finland and Eastern Industries, a local group, with affiliations in the construction, steel and ready-mix industries.[34]

Vietnam.—Vietnam produced 5.2 million tons of cement in 1994, 1.3 million tons was imported in order to meet demand.[35]

A number of new cement plants were to be constructed in Vietnam. Lafarge Coppee and a local Vietnamese partner were to build a new plant with 1,200-ton-per-day capacity. The total project cost was estimated at $40 million.[36] Technip-CLE of France was to be the main contractor for the new But Son cement plant to be located 70 kilometers south of Hanoi in northern Vietnam and was to have a capacity of 1.4 million tons per year.[37]

Current Research and Technology

Soils and sludges, contaminated with heavy metals or organic compounds, were stabilized and solidified by using readily available, conventional, or byproduct cementitious (hydraulic or pozzolanic) materials, such as portland cement, cement kiln dust, lime kiln dust, slag cement, hydrated lime, and fly ash. The research focused on the use of various combinations of cements, fly ash, and byproduct kiln dusts, to stabilize and solidify a wide range of contaminated materials.[38]

The heat of hydration of normal portland cement could cause an increase in concrete temperatures that may result in undesired cracks upon hardening of the cement. The paper discussed alternatives to lowering the heat of hydration and the benefits of adding mineral admixtures such as natural pozzolan, fly ash, and granulated blast furnace slag to control heat of hydration development. For this study, blended cements were prepared using an ordinary portland cement clinker, gypsum, and mineral admixtures, previously ground in a laboratory mill.[39]

The hydration behavior of blended cements containing fly ash, silica fume, and granulated blast furnace slag over the temperature range of 10° to 55°C was studied by isothermal calorimetry. The rates of heat evolution during the first 24 hours of hydration were examined. The results were analyzed to determine the kinetics of hydration of portland and blended cements. Relationships between the reactivities of these blended cements and the curing temperature were established. The results showed that the rates of hydration reactions increased with an increase in temperature in all instances. Comparison among the blends containing fly ash, silica fume, and slag was made to establish activation energies for the hydration reactions.[40]

An investigation was carried out to study the effect of the magnesium-sodium sulfate environment on the performance of two plain and three blended cements; and to determine the sulfate mechanisms on these cements in the mixed magnesium and sodium sulfate environment. After 2 years of exposure, deterioration was observed in all cements, however, the deterioration was more pronounced in blast furnace slag and silica fume cements. Deterioration in these cements significantly exceeded that observed in plain and fly ash blended cements. X-Ray diffraction analyses indicated that the greater deterioration in blast furnace and silica fume blended cements could be attributable to the depletion of the hydrated calcium hydroxide as a result of pozzolanic reaction. In the absence of calcium hydroxide, magnesium ions react more directly and extensively with the cementitious calcium silicate hydrate to generate gypsum and noncementitious magnesium silicate hydrate resulting in aggravated deterioration.[41]

Outlook

Portland cement consumption was expected to decline somewhat from the historic level reached in 1994, since that year witnessed a strong economy and major rebuilding from flooding. However, it was expected to remain high for a couple of years. Cement plants were expected to run at full capacity utilization, with shortages of cement in some areas.

Cement prices were expected to remain at the same levels that had been attained in 1993 and 1994.

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TABLE 1
SALIENT CEMENT STATISTICS

(Thousand metric tons unless otherwise specified)

		1990	1991	1992	1993	1994
United States 1/						
Production 2/		69,954	67,193	69,585	73,807	77,948
Shipments from mills 2/ 3/		78,199	68,999	69,203	74,079 r/ 4/	80,490 4/
Value 2/ 3/ 4/	thousands	$4,280,105	$3,832,096	$3,779,286	$4,174,818 r/ 4/	$4,981,017 4/
Average value per ton 2/ 3/ 5/		$54.73	$55.54	$54.61	$56.36 r/ 4/	$61.88 4/
Stocks at mills, 2/ Dec. 31		5,637	6,009	5,272	4,788	4,805
Exports		503	633	746	625	633
Imports for consumption		12,041	7,893	6,166	7,060	11,303
Consumption, apparent 6/ 7/		81,305	74,000	75,400	80,514 r/	91,160
World: Production		1,156,529 r/	1,184,530	1,241,217	1,303,360	1,369,080 e/

e/ Estimated. r/ Revised.

1/ Excludes Puerto Rico and the U.S. Virgin Islands.

2/ Portland and masonry cement only.

3/ Includes imported cement shipped by domestic producers.

4/ Includes Puerto Rico.

5/ Value received, f.o.b. mill, excluding cost of containers.

6/ Quantity shipped plus imports minus exports.

7/ Adjusted to eliminate duplication of imported clinker and cement shipped by domestic cement manufacturers.

TABLE 2
PORTLAND CEMENT PRODUCTION, CAPACITY, AND STOCKS IN THE UNITED STATES BY DISTRICT 1/

District	1993					1994				
			Capacity 2/					Capacity 2/		
	Plants active during year	Production 4/ (thousand metric tons)	Finish grinding (thousand metric tons)	Percent utilized	Stocks 3/ at mills, Dec. 31 (thousand metric tons)	Plants active during year	Production 4/ (thousand metric tons)	Finish grinding (thousand metric tons)	Percent utilized	Stocks 3/ at mills, Dec. 31 (thousand metric tons)
New York and Maine	5	3,298	4,550	72.5	227	5	3,005	4,141	72.6	217
Pennsylvania, eastern	8	3,848	4,833	79.6	339	8	4,014	4,878	82.3	196
Pennsylvania, western	4	1,517	1,961	77.4	139	4	1,616	2,009	80.4	111
Illinois	4	2,431	2,971	81.8	102	4	2,585	3,217	80.4	127
Indiana	4	2,065	2,708	76.3	165	4	2,291	2,867	79.9	116
Michigan	5	5,115	5,756	88.9	314	5	5,160	6,532	79.0	226
Ohio	4	1,494	2,064	72.4	78	3	1,054	1,588	66.4	37
Iowa, Nebraska, South Dakota	6	3,656	5,761	63.5	265	6	3,891	5,758	67.6	291
Kansas	4	1,382	1,796	76.9	109	4	1,644	1,801	91.3	127
Missouri	5	4,057	4,808	84.4	334	5	4,725	5,059	93.4	340
Florida	6	3,470	4,770	72.7	193	6	3,371	4,382	76.9	291
Georgia and South Carolina	5	3,212	4,368	73.5	246	5	3,256	4,599	70.8	154
Maryland, Virginia, West Virginia	6	3,036	4,082	74.4	244	6	3,237	3,987	81.2	203
Alabama	5	3,748	4,481	83.6	219	5	3,976	4,573	86.9	268
Kentucky, Mississippi, Tennesse	4	2,010	2,129	94.4	178	4	1,983	2,128	93.2	139
Arkansas and Oklahoma	4	2,461	2,762	89.1	167	4	2,434	2,694	90.3	166
Texas, northern	6	3,519	4,466	78.8	191	6	3,809	4,512	84.4	209
Texas, southern	6	4,609	5,529	83.4	131	6	4,815	5,529	87.1	182
Arizona and New Mexico	3	1,707	2,288	74.6	46	3	1,967	2,288	86.0	51
Colorado and Wyoming	4	1,867	2,377	78.5	100	4	1,822	2,377	76.7	97
Idaho, Montana, Nevada, Utah	6	2,064	2,312	89.3	142	6	2,180	2,422	90.0	174
Alaska, Hawaii, Oregon, Washington	4	1,769	2,204	80.3	143	4	1,861	2,295	81.1	180
California, northern	3	2,427	2,867	84.7	80	3	2,616	2,776	94.2	141
California, southern	8	6,084	7,725	78.8	236	8	7,023	7,933	88.5	258
Total or average 5/	119	70,845	89,567	79.1	4,389	118	74,335	90,346	82.3	4,301
Puerto Rico	2	1,310	1,957	66.9	33	2	W	W	71.8	W

W Withheld to avoid disclosing company proprietary data; included in "Total or average."

1/ Includes Puerto Rico. Includes data for three white cement facilities as follows: California (1), Pennsylvania (1), and Texas (1). Includes data for grinding plants as follows: California (1), Florida (2), Iowa (1), Michigan (1), Ohio (1), Pennsylvania (1), and Texas (1).

2/ Grinding capacity based on fineness necessary to grind Types I and II cement, making allowance for downtime required for maintenance.

3/ Includes imported cement. Source of imports withheld to avoid disclosing company proprietary data.

4/ Includes cement produced from imported clinker.

5/ Data may not add to totals shown because of independent rounding.

TABLE 3
CLINKER CAPACITY AND PRODUCTION IN THE UNITED STATES IN 1994, 1/ BY DISTRICT

District	Active plants Process used Wet	Active plants Process used Dry	Active plants Process used Both	Total	Number of kilns	Daily capacity (thousand metric tons)	Average number of days maintenance	Apparent annual capacity 2/ (thousand metric tons)	Production 3/ (thousand metric tons)	Percent utilized
New York and Maine	4	1	–	5	6	11	105	2,985	2,804	93.9
Pennsylvania, eastern	2	5	–	7	15	14	48	4,334	3,881	89.5
Pennsylvania, western	3	1	–	4	8	6	49	1,891	1,630	86.2
Illinois	–	4	–	4	8	8	28	2,568	2,332	90.8
Indiana	2	2	–	4	8	9	43	2,758	2,317	84.0
Michigan	1	2	–	3	8	13	40	4,147	3,896	93.9
Ohio	1	1	–	2	3	3	17	1,094	901	82.4
Iowa, Nebraska, South Dakota	–	4	1	5	9	13	41	4,123	3,637	88.2
Kansas	2	2	–	4	11	6	37	1,823	1,588	87.1
Missouri	2	3	–	5	7	13	36	4,411	4,322	98.0
Florida	2	2	–	4	7	9	36	2,971	2,826	95.1
Georgia and South Carolina	2	2	1	5	11	11	36	3,759	3,192	84.9
Maryland, Virginia, West Virginia	2	3	–	5	15	11	38	3,563	3,110	87.3
Alabama	–	5	–	5	7	14	36	4,495	3,816	84.9
Kentucky, Mississippi, Tennesse	2	2	–	4	5	6	31	1,971	1,887	95.7
Arkansas and Oklahoma	2	2	–	4	10	8	41	2,532	2,373	93.7
Texas, northern	3	3	–	6	14	12	35	4,014	3,770	93.9
Texas, southern	–	4	1	5	6	13	35	4,242	3,817	90.0
Arizona and New Mexico	–	3	–	3	9	7	18	2,448	1,881	76.8
Colorado and Wyoming	1	3	–	4	6	6	30	1,938	1,699	87.7
Idaho, Montana, Nevada, Utah	4	2	–	6	9	6	24	2,010	2,069	102.9
Alaska, Hawaii, Oregon, Washington	1	3	–	4	4	5	30	1,775	1,652	93.1
California, northern	–	3	–	3	3	9	61	2,616	2,567	98.1
California, southern	–	7	–	7	15	22	46	7,187	6,556	91.2
Total or average 4/	36	69	3	108	204	234	NA	75,653	68,525	90.6
Puerto Rico	–	2	–	2	2	5	42	1,546	1,262	81.6

NA Not Available.

1/ Includes Puerto Rico and white cement producing facilities.

2/ Calculated on individual company data; 365 days minus average days for maintenance times the reported 24 hour capacity.

3/ Includes production reported for plants that added or shut down kilns during the year.

4/ Data may not add to totals shown because of independent rounding.

TABLE 4
RAW MATERIALS USED IN PRODUCING PORTLAND CEMENT IN THE UNITED STATES 1/

(Thousand metric tons)

Raw materials	1993	1994
Calcareous:		
Limestone (includes aragonite, marble, chalk)	78,958	78,427
Cement rock (includes marl)	19,186	24,243
Coral	754	675
Argillaceous:		
Clay	4,200	4,189
Shale	5,066	5,514
Other (includes staurolite, bauxite, aluminum dross, alumina, volcanic material, other)	442	500
Siliceous:		
Sand and calcium silicate	2,046	2,095
Sandstone, quartzite, other	571	588
Ferrous: Iron ore, pyrites, millscale, other iron bearing material	1,097	1,186
Other:		
Gypsum and anhydrite	3,696	3,873
Blast furnace slag	38	33
Fly ash	888	1,125
Other, n.e.c.	224	135
Total 2/	117,165	122,582

1/ Includes Puerto Rico.

2/ Data may not add to totals shown because of independent rounding.

TABLE 5
MASONRY CEMENT PRODUCTION AND STOCKS IN THE UNITED STATES, BY DISTRICT

District	1993			1994		
	Plants active during year	Production (thousand metric tons)	Stocks 1/ at mills, Dec. 31 (thousand metric tons)	Plants active during year	Production (thousand metric tons)	Stocks 1/ at mills, Dec. 31 (thousand metric tons)
New York and Maine	5	84	19	5	89	17
Pennsylvania, eastern	6	165	39	6	161	25
Pennsylvania, western	4	83	13	4	84	13
Illinois	--	--	(2/)	1	W	W
Indiana	4	W	W	4	W	31
Michigan	5	216	38	5	235	24
Ohio	3	W	W	2	W	W
Iowa, Nebraska, South Dakota	4	49	6	4	58	12
Kansas	4	W	20	3	24	W
Missouri	3	W	W	1	W	W
Florida	4	351	29	4	400	W
Georgia and South Carolina	4	374	30	4	417	39
Maryland, Virginia, West Virginia	5	199	20	6	571	52
Alabama	4	277	39	5	312	36
Kentucky, Mississippi, Tennessee	3	105	13	3	105	11
Arkansas and Oklahoma	4	102	17	4	104	14
Texas, northern	4	93	9	4	106	10
Texas, southern	5	152	16	5	151	15
Arizona and New Mexico	3	W	4	3	W	W
Colorado and Wyoming	2	W	W	2	W	W
Idaho, Montana, Nevada, Utah	2	W	W	4	W	W
Alaska, Hawaii, Oregon, Washington	2	W	4	2	W	2
California, northern	1	W	W	1	W	W
California, southern	2	W	W	2	W	W
Total or average 3/	83	2,962	399	84	3,613	400

W Withheld to avoid disclosing company proprietary data; included in "Total or average."

1/ Includes imported cement.

2/ Less than 1/ 2 unit.

3/ Data may not add to totals shown because of independent rounding.

TABLE 6
CLINKER PRODUCED AND FUEL CONSUMED BY THE PORTLAND CEMENT INDUSTRY IN THE UNITED STATES, 1/ BY PROCESS

Process	Clinker Produced			Fuel Consumed			Waste Fuel		
	Plants active during year	Quantity (thousand metric tons)	Percent of total	Coal (thousand metric tons)	Oil (thousand liters)	Natural Gas (thousand cubic meters)	Tires (thousand metric tons)	Solid (thousand metric tons)	Liquid (thousand liters)
1993:									
Wet	37	19,700	29.4	3,328	10,152	231,111	20	74	489,988
Dry	72	44,696	66.8	6,298	35,386	375,769	50	15	253,706
Both	4	2,561	3.8	408	8	61,143	--	--	--
Total 2/	113	66,957	100.0	10,034	45,546	668,024	70	90	743,693
1994:									
Wet	36	18,605	26.7	3,197	10,913	174,815	26	58	369,078
Dry	71	49,333	70.7	6,984	37,858	411,657	90	16	230,577
Both	3	1,849	2.6	303	--	63,676	4	--	--
Total 2/	110	69,787	100.0	10,484	48,771	650,148	120	74	599,655

1/ Includes Puerto Rico.

2/ Data may not add to totals shown because of independent rounding.

TABLE 7
ELECTRIC ENERGY USED AT PORTLAND CEMENT PLANTS IN THE UNITED STATES, 1/ BY PROCESS

Process	Electric energy used: Generated at portland Cement plants: Plants active during year	Generated at portland Cement plants: Quantity (million kilowatt-hours)	Purchased: Plants active during year	Purchased: Quantity (million kilowatt-hours)	Total: Quantity (million kilowatt-hours)	Total: Percent	Finished cement produced (Thousand metric tons)	Average electric energy used (per ton of cement produced kilowatt-hours)
1993:								
Wet	1	149	34	2,412	2,562	25.6	20,303	12.6
Dry	6	571	65	6,449	7,020	70.2	47,290	14.8
Both	–	–	4	421	421	4.2	2,677	15.7
Total 2/	7	720	103	9,282	10,002	100.0	70,270	14.2
Percent of total electric energy used	–	7.2	–	92.8	–	–	–	–
1994:								
Wet	–	–	35	2,675	2,675	24.6	19,295	13.9
Dry	5	593	69	7,288	7,882	72.5	51,409	15.3
Both	–	–	3	310	310	2.9	1,957	15.8
Total 2/	5	593	107	10,273	10,866	100.0	72,661	15.0
Percent of total electric energy used	–	5.5	–	94.5	–	–	–	–

1/ Includes Puerto Rico.

2/ Data may not add to totals shown because of independent rounding.

TABLE 8
SHIPMENTS OF PORTLAND CEMENT FROM MILLS IN THE UNITED STATES, 1/ IN BULK AND IN CONTAINERS, BY TYPE OF CARRIER

(Thousand metric tons)

	Shipments from plant to terminal: In bulk	Shipments from plant to terminal: In containers	Shipments to ultimate consumer: From plant to consumer: In bulk	From plant to consumer: In containers	From terminal to consumer: In bulk	From terminal to consumer: In containers	Total shipments 3/
1993:							
Railroad	8,879	89	3,782	495	490	41	4,808
Truck	2,955	131	41,040	1,822	19,063	454	62,378
Barge and boat	6,319	12	582	–	477	–	1,059
Unspecified 2/	484	–	2,377	12	455	15	2,859
Total 3/	18,637	232	47,780	2,329	20,485	510	71,104 4/
1994:							
Railroad	8,871	56	3,205	419	840	15	4,479
Truck	2,667	124	41,701	2,010	25,712	818	70,241
Barge and boat	8,046	–	659	3	294	–	956
Unspecified 2/	1,742	–	643	36	533	16	1,228
Total 3/	21,326	180	46,208	2,468	27,378	849	76,903 5/

1/ Includes Puerto Rico.

2/ Includes cement used at plant.

3/ Data may not add to totals shown because of independent rounding.

4/ Bulk shipments were 96.0% and container (bag) shipments were 4.0%.

5/ Bulk shipments were 95.7% and container (bag) shipments were 4.3%.

TABLE 9
PORTLAND CEMENT SHIPPED BY PRODUCERS IN THE UNITED STATES, BY DISTRICT 1/

District	1993			1994		
	Quantity (thousand metric tons)	Value (thousands)	Average per ton	Quantity (thousand metric tons)	Value (thousands)	Average per ton
New York and Maine	3,055	$154,901	$50.70	3,099	$163,141	$52.64
Pennsylvania, eastern	3,780	195,824	51.81	4,141	221,121	53.40
Pennsylvania, western	1,484	81,501	54.92	1,520	95,171	62.61
Illinois	2,592	130,962	50.53	2,524	147,721	58.53
Indiana	2,235	117,638	52.63	2,293	132,487	57.78
Michigan	4,922	301,425	61.24	5,135	329,409	64.15
Ohio	1,428	86,338	60.46	1,063	70,273	66.11
Iowa, Nebraska, South Dakota	3,467	210,971	60.85	3,722	239,483	64.34
Kansas	1,560	83,390	53.46	1,708	104,988	61.47
Missouri	4,274	211,765	49.55	5,054	283,013	56.00
Florida and Puerto Rico	4,737	298,328	62.98	5,242	395,381	75.43
Georgia and South Carolina	3,442	181,546	52.74	3,334	215,100	64.52
Maryland, Virginia, West Virginia	3,092	157,658	50.99	3,338	185,519	55.58
Alabama	3,345	170,300	50.91	3,839	239,220	62.31
Kentucky, Mississippi, Tennessee	2,255	113,196	50.20	2,323	144,977	62.41
Arkansas and Oklahoma	2,335	107,946	46.23	2,401	140,899	58.68
Texas, northern	3,377	178,152	52.75	3,350	192,328	57.41
Texas, southern	4,677	215,887	46.16	4,872	242,347	49.74
Arizona and New Mexico	1,707	107,621	63.05	1,932	126,565	65.51
Colorado and Wyoming	2,120	138,420	65.29	1,951	135,254	69.33
Idaho, Montana, Nevada, Utah	2,034	147,731	72.63	2,341	175,730	75.07
Alaska, Hawaii, Oregon, Washington	1,518	131,399	86.56	1,568	124,158	79.18
California, northern	1,935	109,608	56.64	1,933	123,062	63.66
California, southern	5,732	312,291	54.48	6,341	339,231	53.50
Total 2/ 3/ 4/ 5/ 6/ or average	71,104	3,944,796	55.48	76,903	4,696,198	61.07

1/ Includes Puerto Rico. Includes data for three white cement facilities as follows: California (1), Pennsylvania (1), and Texas (1). Includes data for grinding plants as follows: California (1), Florida (2), Iowa (1), Michigan (1), Ohio (1), Pennsylvania (1), and Texas (1).

2/ Includes cement produced from imported clinker.

3/ Data may not add to totals shown because of independent rounding.

4/ Cement imported and distributed by domestic producers only.

5/ Does not include cement consumed at plant.

6/ Total includes imports shipped by independent importers.

TABLE 10
MASONRY CEMENT SHIPPED BY PRODUCERS IN THE UNITED STATES, 1/ BY DISTRICT

District	1993			1994		
	Quantity (thousand metric tons)	Value (thousands)	Average per ton	Quantity (thousand metric tons)	Value (thousands)	Average per ton
New York and Maine	85	$6,319	$74.34	91	$6,823	$75.21
Pennsylvania, eastern	171	12,240	71.58	187	13,518	72.34
Pennsylvania, western	79	6,692	84.71	83	7,658	92.76
Illinois, Indiana, Michigan, Ohio	668	56,785	85.05	723	60,056	83.06
Iowa, Kansas, Missouri, Nebraska, South Dakota	181	10,539	58.09	206	12,852	62.41
Florida	356	27,645	77.65	358	31,022	86.57
Georgia and South Carolina	360	27,859	77.39	396	36,406	91.83
Maryland, Virginia, West Virginia	204	16,184	79.33	531	35,151	66.23
Alabama	260	20,610	79.27	317	29,401	92.86
Kentucky, Mississippi, Tennessee	106	8,108	76.49	119	8,848	74.45
Arkansas, Oklahoma, Texas	322	24,381	75.71	354	26,075	73.70
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming	82	5,146	63.03	110	8,821	80.36
Alaska, California, Hawaii, Oregon, Washington	103	7,515	73.31	110	7,738	70.49
Total 2/ 3/ 4/ or average	2,975	230,022	77.32	3,587	284,819	79.40

1/ Does not include quantities produced on the job by masons.

2/ Calculated on unrounded data.

3/ Data may not add to totals shown because of independent rounding.

4/ Total includes imports shipped by independent importers.

TABLE 11
CEMENT SHIPMENTS, BY DESTINATION AND ORIGIN 1/

(Thousand metric tons)

Destination and origin	Portland cement		Masonry cement	
	1993	1994	1993	1994
Destination:				
Alabama	1,296	1,432	122	131
Alaska	106	103	W	W
Arizona	1,845	2,158	W	W
Arkansas	818	880	51	56
California, northern	2,820	2,872	--	--
California, southern	4,846	5,328	W	W
Colorado	2,086	1,746	19	29
Connecticut 2/	587	624	15	12
Delaware 2/	233	230	9	9
District of Columbia 2/	108	112	(3/)	(3/)
Florida	5,262	5,623	437	458
Georgia	2,483	2,751	186	201
Hawaii	442	396	7	6
Idaho	405	456	1	1
Illinois	1,301	1,516	23	30
Chicago, metropolitan 2/	1,998	2,077	50	49
Indiana	1,757	1,876	91	98
Iowa	1,308	1,515	12	13
Kansas	1,124	1,277	15	18
Kentucky	1,180	1,163	86	94
Louisiana 2/	1,689	1,706	46	52
Maine	224	227	5	5
Maryland	1,015	1,083	79	84
Massachusetts 2/	1,002	1,119	24	27
Michigan	2,285	2,585	115	120
Minnesota 2/	1,388	1,518	34	39
Mississippi	880	920	45	75
Missouri	1,882	2,386	38	48
Montana	415	278	1	1
Nebraska	877	1,014	11	12
Nevada	1,131	1,358	(3/)	(3/)
New Hampshire 2/	222	242	6	7
New Jersey 2/	1,425	1,427	54	62
New Mexico	688	665	6	6
New York, eastern	569	514	24	22
New York, western	815	821	34	33
New York, metropolitan 2/	783	1,010	35	38
North Carolina 2/	1,946	2,151	237	253
North Dakota 2/	239	245	3	3
Ohio	3,225	3,482	169	199
Oklahoma	1,051	1,114	35	43
Oregon	818	946	(3/)	(3/)
Pennsylvania, eastern	1,756	1,967	57	61
Pennsylvania, western	1,080	1,102	73	73
Rhode Island 2/	134	152	3	3
South Carolina	970	981	106	113
South Dakota	331	338	5	5
Tennessee	1,536	1,711	165	187
Texas, northern	3,784	3,817	133	134
Texas, southern	3,810	4,053	83	108
Utah	910	1,020	2	2
Vermont 2/	107	101	4	3
Virginia	1,621	1,716	145	146
Washington	1,623	1,723	5	6
West Virginia	441	437	32	33
Wisconsin	1,811	1,889	41	41
Wyoming	230	275	1	2
U.S. total 4/	76,717	82,232	2,984	3,250
Foreign countries 5/	345	377	53	75
Puerto Rico	1,306	1,392	--	--
Total shipment 4/	78,368	84,001	3,037	3,325

See footnotes at end of table.

TABLE 11-Continued
CEMENT SHIPMENTS, BY DESTINATION AND ORIGIN 1/

(Thousand metric tons)

Destination and origin	Portland cement		Masonry cement	
	1993	1994	1993	1994
Origin:				
United States 6/	71,053	75,130	2,901	3,283
Puerto Rico	1,306	1,392	--	--
Foreign: 7/	6,009	8,870	136	42
Total shipment 4/	78,368	84,001	3,037	3,325

W Withheld to avoid disclosing company proprietary data; included with "Foreign countries."

1/ Includes cement produced from imported clinker and imported cement shipped by domestic producers, Canadian cement manufacturers, and other importers. Includes Puerto Rico.

2/ Has no cement producing plants.

3/ Less than 1/2 unit.

4/ Data may not add to totals shown because of independent rounding.

5/ Direct shipments by producers to foreign countries and U.S. possessions and territories; includes States indicated by the symbol W.

6/ Includes cement produced from imported clinker by domestic producers.

7/ Imported cement distributed by domestic producers, Canadian cement manufacturers, and other importers. Origin of imports withheld to avoid disclosing company proprietary data.

TABLE 12
CEMENT SHIPMENTS 1/, BY DESTINATION (REGION AND SUBREGION)

Region and subregion 2/	Portland cement				Masonry cement			
	Thousand metric tons		Percent of grand total		Thousand metric tons		Percent of grand total	
	1993	1994	1993	1994	1993	1994	1993	1994
Northeast:								
New England	2,276	2,466	3	3	56	57	2	2
Middle Atlantic	6,428	6,841	8	8	278	289	9	9
Total	8,704	9,307	11	11	334	346	11	11
South:								
Atlantic	14,078	15,084	19	18	1,233	1,297	41	40
East Central	4,892	5,226	6	6	419	487	14	15
West Central	11,152	11,570	15	14	348	392	12	12
Total 3/	30,122	31,881	39	39	2,000	2,176	67	67
Midwest:								
East	12,377	13,425	16	16	490	537	16	17
West	7,149	8,294	9	10	118	137	4	4
Total	19,526	21,719	25	26	608	674	20	21
West:								
Mountain	7,710	7,956	10	10	30	42	1	1
Pacific	10,655	11,368	14	14	12	12	--	(4/)
Total 3/	18,365	19,325	24	24	42	54	1	2
Grand total 3/	76,717	82,232	100	100	2,984	3,250	100	100

1/ Includes imported cement shipped by importers.

2/ Geographic regions as designated by the U.S. Department of Commerce, Bureau of the Census.

3/ Data may not add to totals shown because of independent rounding.

4/ Less Than 1/2 unit.

TABLE 13
PORTLAND CEMENT SHIPMENTS IN 1994, BY DISTRICT OF ORIGIN AND TYPE OF CUSTOMER 1/

(Thousand metric tons)

District of origin	Building Material Dealers	Concrete Product Manufacturers 2/	Ready Mixed Concrete	Contractors 3/	Oil Well, Mining, Waste 4/	Government and Miscellaneous.	Total 6/
New York and Maine	135	304	1,893	78	--	686	3,099
Pennsylvania, eastern	258	615	1,602	172	27	1,467	4,141
Pennsylvania, western	82	231	941	139	19	109	1,520
Illinois	11	220	1,124	145	8	1,017	2,524
Indiana	41	151	1,066	20	--	1,016	2,293
Michigan	268	598	2,112	215	14	1,928	5,135
Ohio	13	141	411	32	4	461	1,063
Iowa, Nebraska, South Dakota	22	424	2,345	397	46	488	3,722
Kansas	17	101	924	96	11	559	1,708
Missouri	118	440	2,838	452	--	1,207	5,054
Florida and Puerto Rico	628	650	2,267	252	20	1,426	5,242
Georgia and South Carolina	154	636	2,272	229	--	42	3,334
Maryland, Virginia, West Virginia	147	506	1,985	168	7	523	3,338
Alabama	302	573	2,526	306	40	93	3,839
Kentucky, Mississippi, Tennessee	148	233	1,788	118	3	33	2,323
Arkansas and Oklahoma	30	92	1,318	258	39	665	2,401
Texas, northern	102	215	1,785	454	348	445	3,350
Texas, southern	346	196	2,193	304	173	1,661	4,872
Arizona and New Mexico	59	318	1,226	84	11	235	1,932
Colorado and Wyoming	51	193	1,477	156	50	24	1,951
Idaho, Montana, Nevada, Utah	19	205	1,382	162	12	559	2,341
Alaska, Hawaii, Oregon, Washington	75	107	1,006	99	--	282	1,568
California, northern	67	242	1,532	54	2	36	1,933
California, southern	353	1,025	4,556	251	124	33	6,341
Total 6/ 7/ or average	3,638	8,482	42,825	4,643	960	16,357	76,903

1/ Includes Puerto Rico.

2/ Concrete product manufacturers included in thousand metric tons: brick/ block- 1,288 in U.S.; precast-800 in U.S. ; pipe- 562 in U.S.; and others- 5,832 in U.S. Other includes unspecified amounts of brick/ block, precast, and pipe.

3/ Contractors included in thousand metric tons: roadpaving- 1,842 in U.S; soil cement- 363 in U.S. and other- 2,340 in U.S. Other includes unspecified amounts of road paving, and soil cement.

4/ Oil well, mining, and waste included in thousand metric tons in U.S.: oil well drilling- 736; mining- 43; and waste stabilization- 181.

5/ Included in this amount are cement shipments which were unspecified by type of customer.

6/ Data may not add to totals shown because of independent rounding.

7/ Total includes imports shipped by independent importers.

TABLE 14
PORTLAND CEMENT SHIPPED FROM PLANTS IN THE UNITED STATES, 1/ 2/ BY TYPE

Type	1993 Quantity (thousand metric tons)	1994 Quantity (thousand metric tons)
General use and moderate heat (Types I and II)	64,806	69,810
High early strength (Type III)	2,659	2,618
Sulfate resisting (Type V)	1,570	1,763
Block	471	463
Oil well	804	937
White	263	519
Portland slag and portland pozzolan	264	422
Expansive	W	W
Regulated fast setting	W	W
Miscellaneous 3/	137	304
Total 4/ 5/ or average	71,104	76,903

W Withheld to avoid disclosing company proprietary data; included in "Total or average."

1/ Includes Puerto Rico.

2/ The value of grey portland cement $54.97 in 1993 and $60.28 in 1994; value of white portland cement $192.40 in 1993 and $177.04 in 1994.

3/ Includes waterproof,and lowheat (Type IV).

4/ Data may not add to totals shown because of independent rounding.

5/ Does not include cement consumed at plant.

TABLE 15
AVERAGE MILL VALUE, IN BULK OF CEMENT IN THE UNITED STATES 1/

(Per metric ton)

Year	Portland cement	Prepared masonry cement 2/	All classes of cement
1993	55.48	77.32	56.36
1994	61.07	79.40	61.88

1/ Includes Puerto Rico. Mill value is the actual value of sales to customers, f.o.b. plant, less all discounts and allowances, less all freight charges from producing plant to distribution terminal if any, less total cost of operating terminal, if any, less cost of paper bags and pallets.

2/ Masonry cement made at cement plants only.

TABLE 16
U.S. EXPORTS OF HYDRAULIC CEMENT AND CEMENT CLINKER, BY COUNTRY

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	Value 1/	Quantity	Value 1/
Bahamas, The	44	2,227	9	546
Canada	502	36,028	510	35,272
Ghana	2	145	(2/)	31
Mexico	21	3,424	62	4,221
Netherlands	2	307	1	223
Other	54	5,641	52	4,896
Total 3/	625	47,772	633	45,189

1/ Free alongside ship (f.a.s.) value is the value of exports at the U.S. seaport, or border port of export, based on the transaction price, including inland freight, insurance, and other changes incurred in placing the merchandise alongside the carrier at the U.S. port of exportation. The value excludes the cost of loading.

2/ Less than 1/2 unit.

3/ Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

TABLE 17
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY COUNTRY

(Thousand metric tons and thousand dollars)

Country	1993			1994		
	Quantity	Value		Quantity	Value	
		Customs 1/	C.i.f. 2/		Customs 1/	C.i.f. 2/
Canada	3,629	147,747	158,670	4,268	168,603	183,314
Colombia	550	18,017	23,201	709	24,830	31,351
France	216	14,833	17,237	474	27,088	32,538
Greece	282	8,884	11,931	914	31,919	44,060
Japan	43	1,667	2,116	14	668	891
Korea, Republic of	33	891	1,254	--	--	--
Mexico	783	29,074	35,482	640	25,573	31,097
Spain	597	25,745	31,382	1,342	54,585	64,771
Venezuela	269	9,837	12,344	803	32,735	42,090
Other	659	26,436	37,721	2,139	77,036	107,620
Total 3/	7,060	283,131	331,337	11,303	443,038	537,731

1/ Customs value price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandisc to the United States.

2/ C.i.f. (Cost, insurance and freight) import value represents the landed value of the merchandise at the first port of arrival in the United States. It is computed by adding "import charges" to the "customs value."

3/ Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

TABLE 18
U.S. IMPORTS FOR CONSUMPTION OF CLINKER, BY COUNTRY

(Thousand metric tons and thousand dollars)

Country	1993			1994		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f. 1/		Customs	C.i.f. 1/
Australia	133	4,518	6,417	103	3,675	5,414
Canada	883	27,917	28,262	913	31,674	32,261
Colombia	239	6,724	9,060	212	6,370	7,914
France	118	9,458	10,717	154	13,535	15,319
Greece	26	814	1,179	--	--	--
Mexico	--	--	--	(2/)	7	8
New Zealand	78	2,282	3,344	27	837	1,253
Spain	--	--	--	33	912	1,262
Other	30	800	1,074	766	22,773	31,540
Total 3/	1,508	52,513	60,054	2,208	79,783	94,970

1/ Cost, insurance, and freight.

2/ Less than 1/2 unit.

3/ Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

TABLE 19
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY

(Thousand metric tons and thousand dollars)

Customs district and country	1993			1994		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f. 1/		Customs	C.i.f. 1/
Anchorage:						
Canada	6	655	895	1	13	28
China	14	504	679	56	2,147	3,097
Japan	43	1,392	1,782	14	478	672
Total 2/	62	2,551	3,355	71	2,638	3,797
Baltimore:						
Brazil	(3/)	12	14	(3/)	39	46
France	(3/)	2	2	--	--	--
Greece	--	--	--	9	289	410
Japan	(3/)	46	56	(3/)	24	24
Netherlands	(3/)	57	60	--	--	--
Spain	--	--	--	53	1,618	3,094
United Kingdom	(3/)	18	22	(3/)	68	92
Venezuela	--	--	--	13	507	507
Total 2/	(3/)	135	154	74	2,545	4,173
Boston:						
Canada	--	--	--	13	632	707
Germany	--	--	--	(3/)	16	22
Netherlands	(3/)	24	27	--	--	--
Niger	(3/)	12	14	--	--	--
United Kingdom	--	--	--	(3/)	9	9
Total 2/	(3/)	36	41	14	656	739
Buffalo:						
Canada	621	32,841	35,225	532	27,683	30,046
United Kingdom	--	--	--	(3/)	1	1
Total	621	32,841	35,225	532	27,685	30,048
Charleston:						
Canada	--	--	--	43	1,451	2,147
Germany	--	--	--	(3/)	6	8
Greece	--	--	--	23	627	1,020
United Kingdom	(3/)	24	31	(3/)	58	78
Venezuela	--	--	--	12	443	598
Total	1	24	31	78	2,585	3,852
Chicago:						
Japan	(3/)	46	56	(3/)	47	56
Switzerland	(3/)	3	3	--	--	--
Total 2/	(3/)	49	59	(3/)	47	56

See footnotes at end of table.

TABLE 19-Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER,
BY CUSTOMS DISTRICT AND COUNTRY

(Thousand metric tons and thousand dollars)

Customs district and country	1993			1994		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f. 1/		Customs	C.i.f. 1/
Cleveland: Canada	319	10,801	11,243	522	18,032	19,145
ColumbiaSnake:						
China	188	6,891	9,122	243	9,241	11,660
Colombia	--	--	--	4	123	125
Japan	(3/)	2	2	--	--	--
Netherlands	--	--	--	(3/)	1	1
Total 2/	189	6,893	9,124	248	9,366	11,786
Detroit:						
Canada	1,021	39,866	41,070	1,171	45,712	47,525
Japan	(3/)	4	4	--	--	--
Netherlands	--	--	--	(3/)	10	10
Total 2/	1,021	39,869	41,074	1,171	45,721	47,535
Duluth: Canada	93	3,352	3,900	239	8,620	9,964
El Paso: Mexico	91	3,322	4,313	80	3,037	3,944
Great Falls:						
Canada	279	9,679	10,303	220	6,373	7,092
United Kingdom	(3/)	40	47	(3/)	29	35
Total 2/	279	9,719	10,350	220	6,402	7,127
Honolulu:						
Australia	132	4,518	6,417	103	3,675	5,414
Colombia	42	1,134	2,084	--	--	--
New Zealand	78	2,282	3,344	27	837	1,253
Venezuela	--	--	--	26	814	1,404
Total	253	7,933	11,845	157	5,326	8,071
Houston-Galveston:						
Colombia	--	--	--	7	324	438
Denmark	--	--	--	6	308	309
France	--	--	--	68	2,868	3,219
Japan	(3/)	90	111	(3/)	70	82
Singapore	(3/)	2	3	--	--	--
Spain	33	1,365	1,365	529	21,811	23,203
Switzerland	--	--	--	33	1,404	1,734
United Kingdom	(3/)	11	15	(3/)	23	31
Total	33	1,469	1,494	644	26,807	29,016
Laredo:						
China	1	242	266	--	--	--
Mexico	28	2,376	2,710	48	3,978	4,560
Total	29	2,618	2,976	49	3,978	4,560
Los Angeles:						
France	--	--	--	(3/)	22	26
Japan	(3/)	46	54	(3/)	50	57
Mexico	376	14,338	16,747	355	13,393	15,811
Spain	--	--	--	24	828	1,103
Total 2/	376	14,384	16,801	380	14,293	16,996
Miami:						
Belgium	2	219	296	3	251	340
Colombia	208	7,528	9,539	306	11,523	14,636
Denmark	24	1,397	2,138	31	1,886	2,841
Greece	18	664	874	35	1,275	1,647
Norway	--	--	--	64	2,275	2,892
Spain	210	9,911	12,058	288	13,331	15,364
Sweden	--	--	--	158	4,425	6,469
United Kingdom	(3/)	11	11	(3/)	3	3
Venezuela	51	1,910	2,390	47	1,755	2,336
Total 2/	513	21,641	27,307	932	36,724	46,527
Milwaukee:						
Canada	139	4,147	4,884	179	6,056	6,226
Germany	--	--	--	(3/)	1	2
Total 2/	139	4,147	4,884	179	6,057	6,228
Minneapolis: Germany	(3/)	25	28	(3/)	25	26
Mobile:						
Bulgaria	--	--	--	56	1,407	2,201
France	--	--	--	54	1,491	1,843

See footnotes at end of table.

TABLE 19-Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY

(Thousand metric tons and thousand dollars)

Customs district and country	1993			1994		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f. 1/		Customs	C.i.f. 1/
Macao	--	--	--	24	619	850
Morocco	--	--	--	20	543	778
Total 2/	--	--	--	155	4,060	5,673
New Orleans:						
Belgium	(3/)	28	31	--	--	--
Bulgaria	--	--	--	24	599	917
Colombia	--	--	--	43	1,610	2,197
Denmark	--	--	--	103	3,618	5,438
France	37	3,567	3,989	230	9,741	12,755
Greece	--	--	--	363	12,486	17,357
Italy	--	--	--	179	6,165	8,612
Spain	196	7,479	9,224	99	3,613	4,726
Tunisia	--	--	--	26	741	1,115
Turkey	--	--	--	474	14,162	20,311
Ukraine	--	--	--	34	900	1,247
Venezuela	--	--	--	34	1,351	1,826
Total 2/	233	11,074	13,244	1,612	54,988	76,500
New York:						
Greece	182	5,529	7,705	300	11,102	15,300
Netherlands	(3/)	6	7	(3/)	107	114
Norway	--	--	--	78	2,522	3,496
Spain	22	2,008	2,551	208	8,157	10,614
United Kingdom	22	698	904	(3/)	10	11
Total 2/	227	8,242	11,167	586	21,899	29,535
Nogales: Mexico	287	8,848	11,456	156	5,110	6,724
Norfolk:						
Denmark	--	--	--	117	5,865	7,198
France	40	7,192	8,104	84	11,740	12,998
Greece	81	2,691	3,352	183	6,140	8,325
Netherlands	(3/)	57	65	(3/)	16	17
Spain	--	--	--	(3/)	180	199
Venezuela	--	--	--	33	1,260	1,701
Total 2/	122	9,940	11,521	418	25,200	30,438
Ogdensburg:						
Canada	305	10,408	11,260	408	13,246	14,688
Mexico	(3/)	13	13	--	--	--
United Kingdom	(3/)	13	14	--	--	--
Total	306	10,434	11,286	408	13,246	14,688
Pembina: Canada	69	2,148	2,657	120	5,104	5,983
Philadelphia:						
France	(3/)	11	13	--	--	--
Germany	--	--	--	(3/)	6	15
United Kingdom	(3/)	13	16	--	--	--
Total	(3/)	25	29	(3/)	6	15
Portland:						
Bulgaria	--	--	--	28	733	1,028
Canada	5	192	253	10	469	622
Total	5	192	253	38	1,201	1,649
San Diego:						
Mexico	(3/)	13	18	1	56	58
Spain	38	1,652	2,047	28	1,261	1,545
Total 2/	38	1,666	2,065	29	1,317	1,603
San Francisco:						
China	--	--	--	(3/)	2	2
France	--	--	--	(3/)	32	37
Germany	(3/)	2	4	--	--	--
Japan	(3/)	2	4	--	--	--
Korea, Republic of	33	891	1,254	--	--	--
New Zealand	(3/)	13	16	1	738	977
Total 2/	33	908	1,278	1	771	1,016
San Juan:						
Belgium	10	860	1,819	10	838	1,418
Colombia	--	--	--	(3/)	22	29

See footnotes at end of table.

TABLE 19-Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY

(Thousand metric tons and thousand dollars)

Customs district and country	1993			1994		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f. 1/		Customs	C.i.f. 1/
Denmark	9	746	1,259	13	1,157	1,853
Germany	--	--	--	(3/)	5	5
Mexico	1	165	226	--	--	--
Spain	--	--	--	(3/)	7	8
Turkey	--	--	--	(3/)	4	7
Total 2/	20	1,772	3,304	23	2,033	3,319
Savannah: Germany	(3/)	2	3	--	--	--
Seattle:						
Canada	665	30,382	32,634	663	31,141	33,400
China	83	3,041	4,083	17	646	896
Colombia	44	1,485	1,789	100	3,349	3,963
Japan	(3/)	39	47	--	--	--
Total 2/	792	34,946	38,552	780	35,136	38,259
St Albans:						
Canada	67	1,819	2,263	78	2,699	3,543
Netherlands	(3/)	60	68	(3/)	102	116
Total 2/	68	1,878	2,331	79	2,801	3,660
Tampa:						
Canada	29	968	1,429	44	481	877
Colombia	239	7,097	8,902	241	7,531	9,427
Denmark	72	4,135	6,344	79	4,510	6,931
France	139	4,061	5,129	37	1,195	1,661
Spain	100	3,329	4,136	113	3,779	4,915
Sweden	--	--	--	79	2,721	3,705
Turkey	--	--	--	38	1,248	1,616
Venezuela	121	4,396	5,443	450	17,578	22,406
Total 2/	699	23,985	31,384	1,081	39,043	51,538
U.S. Virgin Islands:						
Barbados	11	79	92	--	--	--
Colombia	18	773	887	8	348	536
Denmark	(3/)	1	1	--	--	--
Martinique	--	--	--	4	28	30
Panama	3	94	119	--	--	--
Trinidad and Tobago	9	296	339	8	284	337
Venezuela	44	1,479	1,765	49	3,683	4,130
Total 2/	85	2,721	3,202	70	4,343	5,034
Washington:						
Netherlands	--	--	--	(3/)	3	4
Venezuela	5	244	338	--	--	--
Total 2/	5	244	338	(3/)	3	4
Wilmington:						
Canada	13	492	654	25	893	1,321
Venezuela	47	1,807	2,407	139	5,344	7,183
Total 2/	60	2,300	3,061	164	6,237	8,503
Grand Total 2/	7,060	283,131	331,337	11,303	443,038	537,731

1/ Cost, insurance, and freight.

2 /Data may not add to totals shown because of independent rounding.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 20
U.S. IMPORTS FOR CONSUMPTION OF CEMENT AND CLINKER

(Thousand metric tons and thousand dollars)

Year	Roman, portland, other hydraulic cement		Hydraulic cement clinker		White nonstaining portland cement		Total 1/	
	Quantity	Value (customs)	Quantity	Value (customs)	Quantity	Value (customs)	Quantity	Value (customs)
1993	5,178	199,499	1,508	52,513	375	31,118	7,060	283,131
1994	8,635	329,012	2,208	79,783	459	34,243	11,303	443,038

1/ Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

TABLE 21
HYDRAULIC CEMENT: WORLD PRODUCTION BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Afghanistan e/	112	112	115	115	115
Albania e/	750	600	200	200	200
Algeria	6,340	6,320	6,400	6,400 e/	6,400
Angola e/	260	260	300	250	300
Argentina	3,610 r/	3,400 r/	5,050 r/	5,650 r/	6,000
Armenia e/	XX	XX	500	200	200
Australia	7,070	6,110	5,410	5,500 e/	6,000
Austria	4,900	5,020	5,030 r/	4,940 r/	5,000
Azerbaijan e/	XX	XX	600	400	300
Bahrain	148	150	220 r/	225 r/	225
Bangladesh 3/	337	275	273	275	280
Barbados e/	200	200	175	175	200
Belgium	6,930	7,180	8,070	7,570 r/	8,000
Belarus e/	XX	XX	1,600	1,000	800
Benin e/	300	320	370	380	380
Bolivia	560	592	600	480 r/	500
Bosnia and Herzegovina e/	XX	XX	150	150	150
Brazil	25,800	27,500	24,900	25,900 r/	26,000
Bulgaria	4,710	2,370	2,130 r/	2,500 e/	2,300
Burma	414 r/	435	465	401 r/	453
Cameroon	624	622	620	620 e/	620
Canada	11,700	9,400	5,700	6,670	10,600 4/
Chile	2,120	2,250	2,650	2,600 e/	2,600
China	210,000 r/	253,000	308,000 r/	368,000 r/	400,000 4/
Colombia	6,250	6,300	6,810	6,900 e/	7,000
Congo	90	103	115	114 e/	114
Costa Rica e/	620 4/	700	700	750 r/	780
Côte d'Ivoire e/	500	500	510	500	500
Croatia	XX	XX	1,770 r/	1,680 r/	1,700
Cuba e/	3,000	2,000	2,000	1,000 r/	1,000
Cyprus	1,130	1,130	1,130	1,090 e/	1,040
Czech Republic	XX	XX	XX	5,390 r/	5,300 4/
Czechoslovakia 5/	10,200	8,300	8,500	XX	XX
Denmark (sales)	1,660	2,020	2,070	2,270 r/	2,300
Dominican Republic	1,060	1,230	1,370	1,300 e/	1,200
Ecuador	2,250	2,300	2,250	2,200 e/	2,250
Egypt	14,100	16,400	17,000	16,000 r/	16,000
El Salvador	641	680	419	861 r/	850
Eritrea e/	--	--	--	30	40
Estonia e/	XX	XX	600	500	500
Ethiopia	340	290	300 r/	270 r/ e/	260 4/
Fiji	78	79	84	80 r/	94 4/
Finland	1,670	1,320	1,130	835 r/	870 4/
France	26,400	26,500	21,200	19,300 r/	20,200
Gabon	116	117	116	132	126
Georgia e/	XX	XX	1,000	700	500
Germany:					
Eastern states	7,230	XX	XX	XX	XX
Western states	30,500	XX	XX	XX	XX
Total	37,700	34,400	37,500	36,600 r/	40,400 4/
Ghana	675	750	1,020	1,200	1,350 4/
Greece	13,600	11,800 r/	10,700 r/	12,600 r/	12,600 4/
Guadeloupe e/	225	240	235	230	230
Guatemala	1,680	1,440	1,400 e/	1,450 r/	1,480
Haiti e/	200	250	200	100	75
Honduras	652	693	650 e/	645 e/	645
Hong Kong	1,810	1,680	1,640	1,710	1,930 4/
Hungary	3,930	2,530	2,240	2,530 r/	2,810 4/
Iceland	114	106	100	86 r/	83 4/
India	49,000	51,000	50,000 e/	53,800 r/	54,000
Indonesia	13,800	16,200	17,300	18,900 r/	19,000
Iran e/	13,000	15,000	18,000	18,000 r/	20,000
Iraq e/	10,000	5,000	10,000	12,000 r/	12,000
Ireland e/	1,630	1,600	1,600	1,600	1,550

See footnotes at end of table.

TABLE 21--Continued
HYDRAULIC CEMENT: WORLD PRODUCTION BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Israel	2,870	3,550 e/	3,500	3,500 e/	3,500
Italy	40,000	40,800	41,300	42,000 e/	40,000
Jamaica	442	395	481	451 r/	446 4/
Japan	84,400	89,600	88,300	88,000 r/	91,500 4/
Jordan	1,820	1,750	2,730	681 r/	680
Kazakhastan e/	XX	XX	6,000	5,000	4,000
Kenya	1,510	1,420	1,510	1,500	1,500
Korea, North e/	16,000	16,000	17,000	17,000	17,000
Korea, Republic of	33,600	35,000	44,400 r/	47,300 r/	52,100 4/
Kuwait	900	300	500	500 e/	800
Kyrgyzstan e/	XX	XX	1,000	800	600
Latvia e/	XX	XX	400	300	300
Lebanon e/	900	900	1,000	1,000	1,000
Liberia	49	2	8	8 e/	--
Libya	2,700	2,370	2,300	2,300 e/	2,300
Lithuania e/	XX	XX	2,000	1,500	1,500
Luxembourg	636	688	600 e/	600 e/	620
Macedonia e/	XX	XX	500	500	560
Madagascar e/	60	60	60	60	60
Malawi	99	120	112	127 r/	130
Malaysia	5,880	7,450	8,370	8,800 r/	9,970 4/
Mali e/	20	20	20	20	20
Martinique e/	250	245	240	220	225
Mauritania	104 r/	105 r/	122 r/	111 r/	374 4/
Mexico	23,800	25,100	26,900	27,100	29,700 4/
Moldova e/	XX	XX	1,700	1,500	1,000
Mongolia	441	227	133	82 r/	86 4/
Morocco e/	4,200	5,770	6,340 4/	6,300	6,300
Mozambique e/	79 4/	80	30	20	20
Nepal	107	136	196	190 r/	190
Netherlands	3,730	3,550	3,300 r/	3,400 e/	3,400
New Caledonia	65 e/	90	90	90 e/	90
New Zealand	750 e/	576	579	600 e/	605
Nicaragua	1,200 r/	219 r/	239 r/	277 r/	275
Niger	20	20	29	29 e/	30
Nigeria e/	3,500	3,500	3,500	3,500	3,500
Norway	1,260	1,150	1,270	1,340 r/	1,440 4/
Oman	1,000	995	970	1,000 r/	1,000
Pakistan	7,490	7,760	7,790	8,320 r/	8,300
Panama e/	300 4/	300	250	300	350
Paraguay e/	326	326	326	326	326
Peru	2,190	2,200 e/	2,090	2,090	2,100
Philippines	6,360	6,910	6,730	7,960 r/	9,600 4/
Poland	12,500	12,000	11,900	12,200	13,900 4/
Portugal e/	7,280	7,470	7,640	7,600	7,500
Qatar	267	527	544	544 e/	545
Romania	9,470 r/	6,690 r/	6,270 r/	6,240 r/	8,000
Russia e/	XX	XX	64,000	60,000	50,000
Rwanda e/	60 4/	60	60	60	10
Saudi Arabia	12,000	11,400	15,300	15,300 e/	16,000
Senegal	470	503	601	590 r/	589
Serbia and Montenegro	XX	XX	2,040	1,090 r/	1,610 4/
Singapore e/	1,850 4/	2,000	1,900	1,900	1,900
Slovakia e/	XX	XX	XX	2,500	2,500
Slovenia e/	XX	XX	950	950	1,000
Somalia e/	40	10	25	25	25
South Africa, Republic of	7,810	7,430 r/	7,030 r/	7,360 r/	7,910 4/
Spain (including Canary Islands)	28,100	28,000	25,100	26,000 e/	26,000
Sri Lanka	400 e/	400 e/	817	676 r/	925 4/
Sudan e/	167 4/	170	250	250	250
Suriname e/	50	50	50	50	50
Sweden	2,480	2,400	2,290 r/	2,200	2,100
Switzerland	5,210	4,700	4,260	4,000 e/	4,000

See footnotes at end of table.

TABLE 21--Continued
HYDRAULIC CEMENT: WORLD PRODUCTION BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Syria	3,500	3,500	3,700	3,800 e/	3,800
Taiwan	18,500 r/	19,400	21,600 r/	24,000	22,700 4/
Tajikistan e/	XX	XX	300	250	200
Tanzania e/	540	540	540	540	540
Thailand	18,100	18,100	21,800	26,900 r/	28,000
Togo	399	388	350	350 e/	350
Trinidad and Tobago	438	485	482	527 r/	583 4/
Tunisia e/	3,300	3,300	3,300	3,300	3,300
Turkmenistan e/	XX	XX	700	500	400
Turkey	24,500 r/	26,100	28,600	31,400 r/	30,600
Uganda e/	27 4/	50	50	5	5
Ukraine e/	XX	XX	20,000	17,000	13,000
U.S.S.R .6/	137,000	127,000 e/	XX	XX	XX
United Arab Emirates	3,260	3,470	3,800	3,500 e/	3,600
United Kingdom	14,700 r/	12,200 r/	11,000 r/	11,200 r/	11,500
United States (including Puerto Rico)	71,400	66,800	71,400	75,100	77,900 4/
Uruguay e/	500	500	500	500	500
Uzbekistan e/	XX	XX	6,000	5,000	5,000
Venezuela	5,230	6,340	6,590	6,840 r/	6,900
Vietnam e/	2,500	3,000	5,000 r/	6,500 r/	7,200
Yemen	828	850	800	800 e/	800
Yugoslavia 7/	7,950	7,500 e/	XX	XX	XX
Zaire	461	250 e/	174	149 r/	150
Zambia	437	367	347 e/	350 e/	350
Zimbabwe	700	865	900 e/	1,000 e/	900
Total	1,160,000 r/	1,180,000 r/	1,240,000 r/	1,300,000 r/	1,370,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 13, 1995.

3/ Data are for the year ending June 30 of that stated.

4/ Reported figure.

5/ Dissolved Dec. 31, 1992.

6/ Dissolved in Dec. 1991.

7/ Dissolved in Apr. 1992.

CHROMIUM

By John F. Papp

In 1994, chromium apparent consumption was 390,000 tons of contained chromium. U.S. supply consisted of recycled and imported chromium materials. The United States recycled about 582,000 tons, gross weight, of stainless steel scrap and imported about 567,000 tons of chromite ore, ferroalloys, chemicals, and pigments valued at about $254 million. The United States exported about 90,300 tons of chromium materials valued at about $70 million. Compared with those of 1993, both quantity and value of chromium materials trade decreased in 1994. *(See table 1.)*

Because the United States has no chromite ore reserves and a limited reserve base, domestic supply has been a concern during every national military emergency since World War I. World chromite resources, mining capacity, and ferrochromium production capacity are concentrated in the Eastern Hemisphere. The National Defense Stockpile (NDS) contains chromium in various forms, including chromite ore, chromium ferroalloys, and chromium metal in recognition of the vulnerability of long supply routes during a military emergency. Recycling is the only domestic supply source of chromium. As a result of reduced threat to the territory of the United States, stockpile goals have been reduced and may be reduced further.

Research is conducted by the Federal Government to reduce U.S. vulnerability to potential chromium supply interruption. That research covers both domestic resource utilization and alternative materials identification. Domestic chromium resources include mineral deposits and recyclable materials. The U.S. Bureau of Mines (USBM) evaluates the development potential of U.S. chromium mineral deposits. The USBM also studies minerals extraction and processing and materials substitution and recycling. Alternative materials research also is conducted by the National Aeronautics and Space Administration, the National Institute of Standards and Technology, the Department of Defense, and the Department of Energy.

World chromite ore reserves are more than adequate to meet anticipated world demand. Operation and transportation are the two major components of chromite ore cost in the marketplace.

Chromium is an essential trace element for human health. However, some chromium compounds are acutely toxic, chronically toxic, and/or carcinogenic. Chromium releases into the environment are regulated by the Environmental Protection Agency (EPA). Workplace exposure is regulated by the Occupational Safety and Health Administration (OSHA).

Legislation and Government Programs

Dissolution of the Soviet Union into the Confederation of Independent States and other independent states at the end of 1991 resulted in the reevaluation of the NDS. The absence of a single large adversary encouraged many to advocate reduction of the NDS. Others argued that history has demonstrated the need for a stockpile because periods of relative peace have been interspersed with conflict and that there is no reason to expect this pattern to change. Based on new international political conditions, the Defense Logistics Agency (DLA) submitted annual materials plans that identified chromium materials for disposal. The Revised Annual Materials Plan for Fiscal Year 1994 (as of September 30, 1994) identified chromite ore for disposal as follows: 45,400 tons of chemical grade, 318,000 tons of metallurgical grade, and 90,700 tons of refractory grade. The Annual Materials Plan for Fiscal Year 1995 identified chromite ore for disposal as follows: 45,400 tons of chemical grade and 318,000 tons of metallurgical grade. As part of the National Defense Authorization Act, DLA was prohibited from selling ferrochromium. DLA reported disposal of chromium materials during the October 1993 through September 1994 fiscal year. DLA reported disposal of 9,940 tons of refractorygrade chromite ore, 193,000 tons of metallurgical-grade chromite ore, and 39,000 tons of ferrochromium. (Disposal here means material set aside for sale, trade, or payment in kind. It does not mean material physically removed from the NDS.)[1] (See *Stocks* section.)

In accordance with the President's November 1982 directive and Public Law 99-591, the DLA continued to upgrade NDS chromite ore to high-carbon ferrochromium. The Agency reported conversion of chromite ore to ferrochromium on a contract year basis. DLA signed a contract with Macalloy Corp., Charleston, SC, in 1990 to upgrade NDS chromite ore. The contract period covers the years 1990–94. Macalloy converted 84,100 tons of chromite ore to about 30,800 tons ferrochromium for DLA during the 1994 contract year. The chromite ore to ferrochromium stockpile conversion program was completed in August 1994. *(See table 2.)*

As part of its plan to modernize the NDS, DLA contracted with Elkem Metals Co., Marietta, OH, to upgrade NDS nonspecification-grade low-carbon ferrochromium into electrolytic (vacuum melting-grade) chromium metal. Elkem converted low-carbon ferrochromium to 835 tons of chromium metal during the October 1993 and September 1994 contract period. The low-carbon ferrochromium to chromium metal conversion program was completed in August 1994. *(See table 3.)*

The OSHA reviewed personal exposure limits for chromium materials. OSHA planned to report the results of its review in 1995.

The U.S. Department of Health and Human Services, Public Health Service, Agency of Toxic Substances and Disease Registry published a fact sheet on chromium dated April 1993. They reported that exposure to chromium happens mostly from breathing workplace air or ingesting water or food from soil near waste sites. Chromium can damage the lungs and cause allergic responses in the skin. Chromium has been found in at least 115 of 1,300 National Priorities List sites identified by the EPA.

The EPA regulated the use and disposal of chromium containing materials. EPA banned the use chromium chemicals for industrial process water cooling towers for corrosion inhibition. It was reported that 90% of industrial cooling tower operators had eliminated the use of chromium chemicals in anticipation of such an EPA ban. However, the remaining 800 operations were given 18 months within which to comply with the new ruling.[2] EPA planned to promulgate air quality standards that require chromium electroplaters and anodizers to reduce its chromium emissions by 99% in 1995. EPA planned to give hard-chromium electroplaters and anodizers 2 years to comply and decorative chromium platers 1 year to comply with the new regulation. EPA collected emission data from U.S. ferrochromium producers as part of its ferroalloy producer emission study. EPA planned to collect and analyze ferroalloy production process emission data to determine achievable and economic emission control levels for that industry. EPA planned to have an emission control proposal completed in 1995.

EPA reported chromium releases and transfers from manufacturing and fabrication facilities. *(See tables 4 and 5.)*

Production

The major marketplace chromium materials are chromite ore and chromium ferroalloys, metal, and chemicals. In 1994, the United States produced chromium ferroalloys, metal, and chemicals, but not chromite ore.

Domestic production data for chromium ferroalloys and metal are developed by the USBM by means of two separate surveys. They are the monthly "Chromite Ores and Chromium Products" and the annual "Ferroalloys." Production by the metallurgical companies listed in table 6 represented 100% of the domestic production shown in the current year of table 7.

Chrome Corp. of America continued development of its chromite property in Montana. Chrome Corp. planned to build a ferrochromium and chromium-nickel alloys plant in North America in a joint venture with FerroCarb Corp. under the name Canadian Steel and Alloys Corp. Chrome Corp. planned to use its Montana chromite resources as its source of chromium units. Chrome Corp. reported 14.6 million tons of chromite resources graded at 26% Cr_2O_3.

Cook Island Region Inc. (CIRI) continued development of its chromite deposit at Red Mountain near Seldovia, AK. CIRI contracted the University of Alaska Fairbanks to conduct smelting tests on Red Mountain chromite in preparation for economic feasibility studies.

JMC (USA) Inc., a subsidiary of Japan Metals and Chemicals Co., began production of high-purity chromium metal at Research Triangle Park, NC. JMC's annual production capacity was planned to reach 24 tons of 99.995% pure chromium metal produced by electrolysis in 1994. Production was planned to be exported to the parent company for use in the electronics industry.

Consumption

Domestic reported consumption of chromite ore and concentrate was 322,000 tons in 1994. Of the total chromite consumed, the chemical and metallurgical industry used 302,000 tons; the refractory industry, 20,100 tons. Domestic reported consumption of chromium ferroalloys and metal was 349,000 tons in 1994.

The metallurgical industry consumed chromite ore to make chromium ferroalloys that are subsequently used to add chromium to ferrous and nonferrous alloys. Stainless steel is the major end use of chromium ferroalloys. The chemical industry consumed chromite for manufacturing sodium bichromate, chromic acid, and other chromium chemicals and pigments. Sodium bichromate is the material from which a wide range of chromium chemicals are made. The primary use of chromium in the refractory industry was in the form of chromite to make refractory bricks to line metallurgical furnaces. *(See tables 8 and 9.)*

Stocks

Reported domestic consumer stocks of chromite ore at consumers' plants were 266,000 tons in 1994. At the 1994 annual rate of chromite ore consumption, consumer stocks represented 10 months of supply in the chemical and metallurgical industry and 10 months of supply in the refractory industry. Producer stocks of chromium ferroalloys, metal, and other chromium materials were 8,070 tons in 1994. Consumer stocks of chromium ferroalloys, metal, and other chromium materials were 14,900 tons in 1994. At the 1994 annual rate of chromium ferroalloy, metal, and other chromium material consumption, producer plus consumer stocks represented 0.8 month of supply. *(See table 10.)* The government maintained the NDS. *(See table 11.)* (See *Legislation and Government Programs* section.)

Prices

Chromium materials are not openly traded. Purchase contracts are confidential information between buyer and seller. However, trade journals report composite prices based on interviews with buyers and sellers and traders declare the value of materials they import or export. Thus industry publications and U.S. trade data are a source of chromium material prices and values, respectively. *(See tables 12, 13, 14, and 19, and figures 1 and 2.)*

Foreign Trade

Chromium material exports from and imports to the United States included chromite ore and chromium chemicals, ferroalloys, metal, and pigments. *(See tables 15 through 18.)*

World Review

The major world chromite ore producing countries are India, Kazakhstan, and South Africa. Brazil, Finland, Turkey, and Zimbabwe are significant chromite ore producing countries. Most chromite ore is smelted in an electric arc furnace to produce ferrochromium for use by the metallurgical industry. Stainless steel manufacture is the major end use of ferrochromium. A small amount of chromite is kiln roasted to produce sodium bichromate, a chemical industry product. A very small amount of chromite ore is used, without chemical modification, as a refractory material. The major ferrochromium producing countries are Kazakhstan, Russia, and South Africa. China, Finland, India, Japan, Sweden, and Zimbabwe are significant ferrochromium producing countries. The major stainless steel producing areas of the world, Europe (including Western Europe and Scandinavia), Japan, and the United States, account for about 70% of world stainless steel production. The major world chromium chemical producing countries are Kazakhstan, Russia, United Kingdom, and the United States. *(See tables 20 through 23.)*

Industry Structure.—The chromium industry is composed primarily of chromite ore producers, ferrochromium producers, and stainless steel producers. Other industry components are chromium chemical and chromite refractory producers. Brazil, Finland, India, Turkey, and the Republic of South Africa are countries that have vertically integrated chromium industry. They mine chromite ore, produce ferrochromium, and produce stainless steel. In Finland, Outokumpu Oy, a major share of which is stateowned, owns and operates the only chromite mining, ferrochromium production, and stainless steel production facilities, making it completely vertically integrated. In the Republic of South Africa, chromium-related companies are privately owned. Typically, major shares of a company are owned by other companies and the remainder, if any, is openly traded. Samancor owns and operates chromite mining and ferrochromium production, and co-owns the only stainless steel production facilities. In Brazil, the mining and smelting of chromium is vertically integrated, but stainless steel production is independent of the mining-smelting operations. The major mining companies are subsidiaries of Cia. de Ferro Ligas da Bahia S.A. Stainless steel is produced primarily by Companhia Acos Especiais Itabira. Other chromite operations in Brazil are also vertically integrated. Bayer AG (Germany) owns a chromite mine and chromium chemical plant. Refractory chromite operations are also vertically integrated from chromite production through refractory material production. Chromite mining and ferrochromium production in India is mostly vertically integrated. Ferro Alloys Corp. is the only stainless steel producer in India that is integrated from chromite ore mining through ferrochromium and stainless steel production. In Japan and Russia, chromite ore production is minor and primarily for refractory industry use. In Japan, some ferrochromium producers are associated with stainless steel plants by location, ownership, or both. In Russia, production facilities are Government owned. In Kazakhstan, chromite ore mining and ferrochromium production is vertically integrated. In Turkey, the chromium industry is composed of both large and small chromite ore producers, with one major producer, Etibank, integrated from mining through ferrochromium production. The chromium industry of Zimbabwe is composed of large companies vertically integrated from chromite mine production through ferrochromium production, small independent chromite mines, and chromite mines operated independently on behalf of the large vertically integrated companies. In China, the chromium industry is concentrated on ferrochromium production. Only minor amounts of chromite ore and moderate amounts of stainless steel are produced in China.

Capacity.—Rated capacity is defined as the maximum quantity of product that can be produced in a period of time at a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Because not all countries or producers make production capacity information available, historical chromium trade data have been used to estimate production capacity. Rated production capacity changes result both from changes in facilities and changes in knowledge about facilities. Capacities have been rated for the chromite ore, ferrochromium, chromium chemical, and chromium metal industries. *(See table 24.)*

Reserves.—The United States has no chromite ore reserves. However, the United States has a reserve base and resources that could be exploited. Domestic and foreign reserve estimates are reported by the USBM in other publications.[3]

Production.—World chromite ore production in 1994 was about 9.6 million tons, a 3% increase over that of 1993. This increase follows 2 years of major decreases (down 22% from 1991 to 1992 and down 18% from 1992 to 1993). World ferrochromium production in 1994 was about 3.50 million tons, a 7% increase over that of 1993. This increase follows 2 years of substantial decline (down 5% from 1991 to 1992 and down 11% from 1992 to 1993). *(See tables 22 and 23.)*

Albania.**—National.**—Albchrome, a semiautonomous organization responsible for the chromite mining and ferrochromium production industry, was established in 1992 for the purpose encouraging private investment in the country's chromium industry. Albchrome negotiated with Metallgesellschaft and Mannesmann AG (Germany) and with Macalloy (United States) and a group of United Kingdom companies to develop a joint-venture partnership.

Chromite Ore.—Chromite ore production rates were reported by source in 1994 to have been: Batra, 100,000 tons per year; Bulqiza, 200,000 tons per year; and Kalimash, 200,000 tons per year at 20% to 22% Cr_2O_3. These production levels were about one-third of potential production rates. The chromite ore resources of Albania were reviewed. Based on capacity estimates by mine and grade by mine, Albania's run-of-mine production capacity was reported to be 1,515,000 tons, with a marketable product of about one-half that amount.[4]

Ferrochromium.—Albania also operated two ferrochromium plants, one at Burrel and one at Elbasan. Production was reported to have been 22,000 tons of high-carbon ferrochromium in 1992 and projected to reach 34,626 tons in 1993.

Australia.—Dragon Mining NL continued development of its Range Well lateritic chromiferous deposit in Western Australia. Dragon planned to use the high-iron content ore to product cast grinding balls by a direct casting and smelting route. Dragon Mining, Pyromet CC (South Africa), and Mintek (South Africa) produced and tested grinding balls from a sample of Range Well ore. The smelting and casting tests are the basis upon which furnace and plant, and capital and operating cost for Range Well are based.

Brazil.**—National.**—Brazil imposed a 27.19% duty on imports of low-carbon ferrochromium from the Confederation of Independent States effective in April for a duration of 5 years subject to annual review. The duty replaced a provisional 18.97% duty. The duty was based on a request by Associação Brasileira Dos Produtores De Ferroligas (ABRAFE) made in November 1992.

Chromite Ore and Ferrochromium.—Cia Ferroligas do Amapa exported chromite in 1993. Companhia de Ferro-Ligas da Bahia S.A. produced chromite ore and smelted it into high- and low-carbon ferrochromium and ferrochromiumsilicon. Departamento Nacional da Produção Mineral reported chromite ore reserves in 1993 to have been 6,900,000 tons of average grade 30.0% Cr_2O_3, production in 1993 of chromite ore was 127,000 tons of contained Cr_2O_3; chromium ferroalloys and metal production, 86,759 tons; and chromium chemical production was 63,000 tons. Brazilian chromium apparent consumption in 1993 was about 140,000 tons of contained chromium, a 17% decrease from 170,000 tons reported for 1992.

***Canada.*—National.**—The government of Canada studied chromium in the environment. Concentrations of dissolved hexavalent chromium in several rivers and streams were found to exceed the effects threshold for most sensitive aquatic species. Environment Canada and Health and Welfare Canada concluded that dissolved and soluble forms of hexavalent chromium are entering or may enter the environment in a quantity or concentration or under conditions that are having or may have a harmful effect on the environment.

Chromite and Ferrochromium.—Ressources Minières Coleraine Inc. planned a high-carbon ferrochromium plant in Quebec. The company sought partners.

***China.*—National.**—China has assumed an increasingly important roll as a consumer of chromite ore and a producer of chromium ferroalloys and metal as shown by China's trade statistics since the late 1980's. China abolished a 10% export rebate on aluminothermic chromium metal.

China reported trade statistics for 1993–94. Chinese chromium trade has been dynamic. China imported chromite ore as follows: 429,808 tons in 1988; 595,783 tons in 1989; 641,268 tons in 1990; 544,649 tons in 1991; 901,021 tons in 1992; 618,757 tons in 1993; and 650,000 tons in 1994. The dramatic increase in Chinese imports of chromite ore reportedly resulted from the conversion of ferroalloy production capacity to ferrochromium partly for foreign sale. In 1993, China produced 345,000 tons of chromium ferroalloys distributed by grade as follows: 210,000 tons of high-carbon ferrochromium; 50,000 tons of medium-carbon ferrochromium; 65,000 tons of low-carbon ferrochromium; and 20,000 tons of ferrochromiumsilicon. From this production, China exported 145,000 tons of chromium ferroalloy distributed by grade as follows: 123,279 tons of high-carbon ferrochromium; 6,442 tons of medium- and low-carbon ferrochromium; and 14,950 tons of ferrochromiumsilicon. China also exported 6,978 tons of chromium metal in 1993, an increase from exports of 6,720 tons in 1992. In 1994, China produced 350,000 tons of chromium ferroalloys distributed by grade as follows: 230,000 tons of high-carbon ferrochromium; 50,000 tons of medium-carbon ferrochromium; 35,000 tons of low-carbon ferrochromium; and 35,000 tons of ferrochromiumsilicon. Chinese stainless steel production was estimated to have been about 300,000 tons in 1993 accounting for about 200,000 tons of domestic ferrochromium consumption. China anticipated its local demand for ferrochromium will increase to 400,000 tons by the year 2000 as a result of growth in domestic stainless steel production to about 800,000 tons in 2000. Chinese chromium apparent consumption was about 130,000 tons in 1993.

Chromite Ore.—The Dongfeng Mine in northern Tibet started chromite ore production in 1967. Since opening, Dongfeng has produced 420,000 tons of chromite. Development of the Luobusa mining complex in south central Tibet started in 1988 and reached opencast production design capacity in 1994. A beneficiation plant is being constructed and plans for underground mining were being made. The complex consists of four mines, two operated by the local government and two operated by cooperatives. Chromite ore annual production capacity was about 50,000 tons and was expected to rise to 130,000 tons when mine construction is complete; run-of-mine ore graded at 45% Cr_2O_3.

Ferrochromium.—China shifted ferroalloy production capacity to ferrochromium production resulting in a greater role for China in chromite ore and ferrochromium markets starting in 1991. As a result, China's ferrochromium exports grew from 8,000 tons in 1987 to 145,000 tons in 1993. Ferrochromium producers in China were reported to have been: Chongqing, Sichuan Province; Emei, Sichuan Province; Hanzhong, Shanxi Province; Hengshan, Zhejiang Province; Hunan, Hunan Province; Jiangyin, Jiangsu Province; Jilin, Jilin Province; Jinzhou, Liaoning Province; Liaoyang, Liaoning Province; Nanjing, Jiangsu Province; Shanghai, Shanghai Municipality; and Xibei, Gansu Province.

Croatia.—Dalmacija Dugi Rat operated a high-carbon ferrochromium smelter composed of three, 20 megawatt furnaces to produce high-carbon ferrochromium containing over 65% chromium with an annual production capacity in the range of 105,000 to 110,000 tons. Dalmacija closed operation in August 1994 owing to insufficient power supply.

Cuba.—Cuba studied the potential of producing high-carbon ferrochromium and ferrochromiumsilicon from Cuban ore graded at 34% Cr_2O_3.

Finland.—The chromium industry of Finland is vertically integrated from chromite ore mining through stainless steel production under Outokumpu Steel Oy. The Kemi chromite deposit was discovered in 1959 followed by a decision to mine in 1964 and industrial scale production in 1968. It is 7 kilometers northeast of Kemi City. Reserves were reported at 70 million tons with resources at 150 million tons of ore. Ore grade is 26% Cr_2O_3 average grade. The ferrochromium plant started production in 1968 with an annual production capacity of 30,000 tons of ferrochromium. Periodic upgrades, including the addition of a new pelletizing plant in 1989, boosted production capacity to its current annual level of 230,000 tons of high-carbon ferrochromium graded at 52% chromium and 6% to 8% carbon. Commercial stainless steel production began in 1976 with a planned annual production capacity of 50,000 tons of stainless steel. Outokumpu supplies about 40% of its ferrochromium needs for stainless steel production as hot metal. It started construction of a new ferrochromium converter that will permit it to supply 90% of its ferrochromium needs as hot metal which, in turn, will increase its stainless steel melt shop capacity from 400,000 to 500,000 tons when the project is completed in 1996. For 1993 Outokumpu reported chromite ore mined at 1.0 million tons, ferrochromium production at 218,000 tons and raw stainless steel production at 371,000 tons. For 1994 Outokumpu reported chromite ore mined at 1.1 million tons, ferrochromium production at 229,000 tons, and stainless steel production at 426,000 tons.

Germany.—Bayer AG's chromium chemicals plant at Leverkusen has been supplying chemicals for its recently closed plants in South Africa and Spain.

***India.*—National.**—The Indian government opened its chromite mining industry to private and foreign investment of up to 50% ownership.

Chromite.—Indian Bureau of Mines (IBM) reported chromite ore total geological resources of 182 million tons, 96% of which was in Cuttack district of Orissa State. Reserves were 88.351 million tons (98% in Orissa, 1% in Karnataka, and the remainder in Andhra Pradesh, Bihar, Maharashtra, Manipur, and Tamil Nadu). The major chromite mining companies were; Tata Iron and Steel Co. Ltd., Orissa Mining Corp. Ltd., Ferro Alloys Corp. Ltd, and Mysore Minerals Ltd. Chromite production was 1,045,513 tons in 1989-90 (average Cr_2O_3 content of 44.4%), and 939,597 tons 1990-91 (average Cr_2O_3 content of 44.5%), 1,087,204 in 1991-92, and 1,064,190 tons in 1992-93. India reported chromite ore domestic consumption of 427,500 tons in 1988, 476,600 tons in 1989-90, and 486,300 in 1990-91. The distribution of production in 1990-91 was 87% to chromium ferroalloy production, 7% to refractory production, and 6% to chemical production.

Orissa Mining Corp. started operation of and shipments of chromite ore from its new beneficiation plant at its Kaliapani Mine, Cuttack District, Orissa State. The plant was planned to consume about 100,000 tons per year of chromite ore graded at 50% Cr_2O_3 to produce about 84,000 tons per year of chromite ore concentrate (62,000 tons of sand and 22,000 tons of fine concentrate) graded at from 54% to 55% Cr_2O_3. SiO_2 was to be kept at under 1%.

Federation of Indian Minerals Industry and Indian Metals and Ferro Alloys Limited reported India's chromite ore reserves to be in the range of 182 to 186 million tons distributed among grades as follows: 40 million tons proven, 80 million tons possible, and 60 million tons probable. The difference between IBM reserves and privately reported reserves results from the difference in definition. IBM surveys to 50 meters depth whereas mining companies survey to greater depth.

Indian Metals and Ferro Alloys sought to increase its chromite ore leases in order to avoid the necessity of buying ore from its competitors. Holdings were distributed as follows: Tata Iron and Steel, 69%; Orissa Mining, 21%; and Ferro Alloys, 4%. Indian Metals and Ferro Alloys and other companies held the remainder. The Indian court approved the extension of Tata's chromite leases and recommended a feasibility study on sharing part of Tata's lease with another mining company.

Ferrochromium.—IBM reported ferrochromium (i.e., ferrochrome plus charge chrome) production of 137,301 tons in 1989-90; 149,966 tons in 1990-91; and 192,674 tons in 1991-92. Reported 1990-91 ferrochrome consumption of 21,750 tons, 90% of which went into alloy steel. The major ferrochromium producers included: Deepak Ferro-Alloys Ltd., Ferro Alloys Corp. Ltd., Indian Metals and Ferro Alloys, Jindal Ferro-Alloys Ltd., Tata Iron and Steel, and Ispat Alloys Ltd. started construction of a 7.5-megavolt-ampere furnace for ferrochromium production. The furnace was planned to have an annual ferrochromium production capacity of 15,000 tons and to start production in 1995.

Chemicals.—Narco Chemicals Ltd. started production of sodium dichromate at the Fatuha Industrial Area of Bihar. Annual production capacity is 875 tons of sodium dichromate, 3,500 tons of basic chromium sulfate, and 2,100 tons of sodium sulfate. The chemicals were to supply the leather tanning industry.

Iran.—Faryab Mining and Chrome Smelting Co. started ferrochromium production from a 12.5-megavolt-ampere furnace for domestic consumption and export. Export was planned to start in 1995. Plant construction started in 1992. Annual ferrochromium production capacity was estimated at about 7,000 tons.

Italy.—The Bettoni Group were ordered by a Brescia Court to cease activity after Bettoni failed to meet debt payments. Included in the group is Fucinati, a ferrochromium producer with 22,000 to 25,000 tons per year production capacity. Fucinati stopped furnace production in 1993 but continued to sell ferrochromium recovered from slag produced as part of a joint venture with Aktubinsk (Kazakhstan).

Japan.—Japan planned to reduce its current ferrochromium import duty of 7.2% by one-third in accordance with the Uruguay Round GATT agreement. Japan's planned ferrochromium import duty reduction schedule is as follows: 1995, 7.2%; 1996, 6.9%; 1997, 6.4%; 1998, 5.8%; and 1999, 5.3%.

Japan operated a two-part stockpiling program, Government and private. Japan's long-term goal was to acquire a stockpile of chromium materials adequate to serve the needs of Japanese industry for 60 days. Japan planned to have the Government finance and stockpile 70% of the material; the private sector, the remaining 30%. They also planned to reach the 60 day-supply target in 1995. Metal Mining Agency of Japan, under the supervision of the Ministry of International Trade and Industry, operated the government stockpile, while Japan Rare Metals Stockpiling Association operated the private stockpile. Japan appropriated money to continue stockpile purchases through fiscal year 1995 (April 1995--March 1996).

Japan imported 664,545 tons of chromite ore, 608,273 tons of ferrochromium, 2,026 tons of chromium metal, and 194,956 tons of stainless steel scrap. Japan's ferroalloy industry produced about 215,924 tons of ferrochromium, a decline of 4% compared with that of 1993. (Japan's annual ferrochromium production has ranged about from 216,000 tons to 360,000 tons in the 1980-93 time period with the lower limit set in 1994.) Japan reported hot rolled stainless steel production of 2,863,878 tons in 1994, an increase of 7% compared with that of 1993. Japan exported 1,168 tons of ferrochromium and 1,038,226 tons of stainless steel. Chromium metal imports showed substantial increases in recent years owing to the closure of Japan's chromium metal producer: 38% increase in 1994, 48% in 1993, 25% in 1992, and 44% in 1991. Japan has become the World's second largest importer of chromium metal. Ferrochromium imports represented 74% of market share (up 3% over 1993) while stainless steel exports represented 36% of production. Japan's ferrochromium industry loss of market share in 1994 was attributed to the high value of the yen compared with the U.S. dollar. Based on chromite ore, ferrochromium, and chromium metal trade, chromium apparent consumption in Japan was about 536,000 tons-contained chromium in 1994.

Chromite in the Tari-Misaka ultramafic complex was studied. The complex hosted the Wakamatsu Mine and the Hirose Mine. Petrological and geochemical data were found to support current models of chromite origin.[5]

Kawasaki Steel started production of stainless steel using a new process. Kawasaki purchased chromite ore for production of prereduced chromite briquetes at its Mizushima plant and ferrochromium for stainless steel production at its Chiba plant. Kawasaki operated two, 160-ton converters. Partially reduced chromite pellets, chromite ore, and ferrochromium were introduced in the first converter. The stainless steel was then decarburized in the second converter. The process was expected to consume about 120,000 tons of chromite ore plus 60,000 tons of ferrochromium to produce about 230,000 tons of stainless steel annually.

Japan Metals and Chemicals' Oguni Works closed its ferrochromiumsilicon furnace electing to use imported ferrochromiumsilicon instead for its low-carbon ferrochromium production.

***Kazakhstan.*—National.**—Chromium related activity centered around reorganization of the industry as a result of national economic and political reorganization. The Kazakhstan chromium industry moved from state control of the chromite ore mining and two ferrochromium plants in 1990 to semi-independent operations in 1991. As a result of that change and the subsequent entrance of Kazakhstani chromium producers into the world market, Kazakhstan is reorganizing its industry. The government organized the chromium industry into holding companies with Donskoy and Aktubinsk in one company (Kramds) and Yermakovsky in another in 1994. Donskoy left Kramds which was subsequently dissolved. Kazakhstan planned to privatize the mining and ferrochromium industries to bring in money necessary to maintain and develop those industries. Production reportedly was low owing to poor maintenance resulting from inadequate money resources.

Chromite Ore.—The mineralogy, petrology, and geochemistry of the podiform chromite deposits of the Kempirsai massif, southern Urals, were reported. The Kempirsai massif hosts the worlds largest podiform chromite deposits. Mine production from the area is about 4 million tons per year and reserves exceed 300 million tons.

Donskoy Ore Dressing Complex mines and beneficiates chromite ore with an annual production capacity of 3.5 million tons.

Ferrochromium.—Aktubinsk Ferroalloy Plant produced ferrochromium from chromite ore from Donskoy Mining Complex.

Yermakovsky Ferroalloy Plant produced ferrochromium from chromite ore from Donskoy Mining Complex. Yermak produced about 230,000 tons of ferrochromium in 1993. Yermak planned to convert furnaces used to produce other ferroalloy to ferrochromium ultimately reaching an annual ferrochromium production capacity of 700,000 tons.

Madagascar.—Kraomita Malagasy mined chromite ore for export in Madagascar. A hurricane in March caused transportation infrastructure damage sufficient to stop exports until November. Kraomita transports its ore by truck to rail a distance of 90 kilometers, then by rail to Toamasina (formerly Tamatave) port a distance of 370 kilometers. Hurricane damage was repaired by August. However, transportation was limited to essential goods until November. Owing to hurricane damage, limited transportation, and limited oil supply, chromite ore production was reduced to about 85,000 tons in 1994 from the 144,500 tons produced in 1993.

Oman.—Oman explored and geologically mapped the country. Already identified are over 2 million tons of chromite ore reserves being mined by Oman Chromite Co.

Pakistan.—Chromite ore production at Muslimbagh mines based in Baluchistan was reported to be about 5,000 tons per year from 20 to 30 open pits. Metallurgical grade chromite was exported to China while chemical grade was consumed domestically.

***Philippines.*—National.**—National Power Corp., the national electrical energy supplier on Mindanao Island, reduced power rates from 1.32 peso per kilowatt-hour to 1.05 peso per kilowatt-hour as a result of abundant rainfall and recovering water levels at Lake Lanao.

Chromite Ore.—Chromite ore production is centered on Luzon Island where Benguet Corp. mines refractory grade chromite from the Coto Mine.

Ferrochromium.—Integrated Chrome Corp. started ferrochromium production in May after having been idle since March 1993. Inchrome started production from its 20 megavolt-ampere furnace at the rate of 2,250 tons of ferrochromium per month. Inchrome suspended production in mid-September. Metro Alloys planned to restart its three furnaces of which one produces 60% to 65% chromium, high-carbon ferrochromium and a second produces 50% to 55% chromium, high-carbon ferrochromium. Ferrochrome Philippines restarted ferrochromium production in April, after having been idle since December 1993, and idled its furnaces again in July.

***Russia.*—Chromite Ore.**—Russian Federation chromite ore reserves were reported at 648 million metric tons, of which the most promising deposit was the Aganozersky Field in Karelia Autonomous Region with reserves of 200 million tons and the Rai-Izsky deposits in the Arctic Urals with reserves of 30.2 million tons.

Chromite ore production was reported to have been 122,200 tons in 1992 and 120,800 tons in 1993. Ferrochromium production was reported to have been 661,700 tons in 1992 and 623,900 tons in 1993. Chromium metal production was reported to have been 8,500 tons in 1992 and 4,200 tons in 1993. Russia exported 172,270 tons of ferrochromium in 1993.

Ferrochromium.—Chelyabinsk Electrometallurgical Works had 32 ferroalloy furnaces ranging in electrical capacity from 3.5-megavolt-amperes to 33-megavolt-amperes. They reported production between 1985–91 to have been about 250,000 tons of chromium ferroalloys per year distributed among low-carbon ferrochromium, foundry grade, and 48% ferrochromiumsilicon.

Serov Ferroalloy Works had 17 ferroalloy furnaces ranging in electrical capacity from 5 megavolt-amperesto 16.5-megavolt-amperes. They reported annual ferroalloy production between 1981–91 to have been about 300,000 tons of chromium ferroalloys per year distributed among low-, medium-, and high-carbon, and foundry ferrochromium and 48%, 33%, and 20% ferrochromiumsilicon. Serov reported production in 1993 of 133,000 tons of high-carbon ferrochromium, 117,000 tons of low- and medium-carbon ferrochromium, and 85,000 tons of ferrochromiumsilicon. Serov planned to construct a briquetting plant to process its chromite ore supply from Kazakhstan, which had been increasingly composed of fines. Serov received about 5% of its chromite ore from Saranovskaya Mine; the remainder was imported from Kazakhstan. Shortage of chromite ore supply in 1994 lead Serov to abandon the briquetting strategy in favor of developing domestic resources.

Klyuchev Ferroalloy Works had seven ferroalloy furnaces. They reported annual ferroalloy production between 1981–91 to have been about 3,500 tons of chromium ferroalloys per year distributed among low-carbon and 40% ferrochromiumsilicon.

Chromium Metal.—Klyuchev Ferroalloy Works from 1985–91 reportedly produced between 12,000 and 16,000 tons of chromium metal per year. Chromium metal production in Russia has declined substantially since 1985 leaving considerable idle capacity.

South Africa, Republic of.—South African economic policy is one of vertical integration of industries that are based on its domestic mineral assets. To this end, the chromium industry of South Africa has moved from being a major world supplier of chromite ore to being the major supplier of both chromite ore and ferrochromium to Western markets. Further vertical integration will result from Columbus' and ISCOR's planned increase in stainless steel production. South Africa planned to increase stainless steel annual production capacity from the current 140,000 tons to 177,000 tons in 1995, 307,000 tons in 1996, and in excess of 1.1 million tons in 2000, most of which was planned for export. This added capacity would account for about one-half of world stainless steel demand growth over the same time period if historical performance is realized over that time period. Rising transportation cost also encouraged local resource processing.

South Africa reported its chromite ore reserve base in 1993 at 3,200 million tons. South Africa reported declining chromite ore production in 1993 of 2,827,000 tons, only 55% of peak production of 5,100,000 tons in 1991. Preliminary production reports for 1994 of 3,590,000 tons shows a significant recovery in 1994. Chromium ferroalloy production in 1993 was reported at 833,600 tons, down from the 1991 peak of 1,149,200 tons but better than 1992 production of 770,600 tons. Preliminary ferrochromium production data for 1994 of 1,104,000 tons shows further recovery in 1994. Reduced chromite ore and ferrochromium production while world stainless steel production remained strong was attributed to increased availability of chromite ore, ferrochromium, and stainless steel scrap from the former Soviet Union and of ferrochromium from China.

Chromite Ore.—Hernic Mining (Pty.) Ltd. expanded its mineral property. Hernic reported it reserves at 23 million tons graded at 39% to 40% Cr_2O_3. Hernic studied the feasibility of setting up a ferrochromium plant. Lebowa Development Corp. negotiated a plan with the National Union of Mineworkers to reopen the Dilokong Mine in 1995. Dilokong has been idle for 2 years. Samancor Ltd., South Africa's largest chromite mining company, reported an annual production capacity of 2.62 million tons from six locations.

Ferrochromium.—Samancor reported annual ferrochromium production capacity of 973,000 tons from five locations. Samancor reported that it planned to commission a slag recovery facility at its Ferrometals plant in 1995 and that it would study the feasibility of such a plant at its Tubatse and Middelburg plants. Upon completion, ferrochromium recovery from slag processing was expected to increase annual ferrochromium production capacity by 50,000 tons at Ferrometals and by 18,000 tons at Tubatse. Samancor conducted trial transfers of hot ferrochromium from the Middelburg ferrochromium plant to Columbus stainless steel plant in anticipation of expanded stainless production at Columbus. Samancor continued developmental operation of the Chrome Direct Reduction (CDR) process kiln at Middelburg to improve metalization and kiln refractory life. A melting furnace to accept the kiln output has yet to be designed and constructed. Upon implementation, the CDR process was anticipated to add 400,000 tons to Middelburg's annual ferrochromium production capacity. Samancor and Showa Denko (Japan) planned a joint venture wherein Showa Denko would transfer low-carbon ferrochromium production technology to Samancor which would then produce that material at its Middelburg plant for sale in Japan and elsewhere.

Chrome Corp. Technology operated three electric furnaces (annual production capacity of 180,000 tons of ferrochromium), one chromium recovery process (annual production capacity of 20,000 tons of ferrochromium), and one pelletizing plant (annual capacity of 18,000 tons of chromite pellets) in 1994 at its Rustenburg plant. Chrome Corp. Technology started installation of a fourth electric furnace. Upon completion in 1995, Chrome Corp. Technology will have an annual production capacity of 260,000 tons of ferrochromium.

Stainless Steel.—Columbus Joint Venture (CJV) was organized and scheduled for formal recognition as a new company in January 1993. CJV is equally co-owned by Highveld Steel and Vanadium Ltd., Samancor Ltd., and Industrial Development Corp. (IDC). (Samancor Ltd. is co-owned by Gencor and Anglo-American Corp. Highveld Steel is co-owned by De Beers and Anglo-American Corp. IDC is state owned.) CJV constructed new production facilities to increase its current annual production capacity of 120,000 tons to 500,000 tons in 1996. ISCOR studied the feasibility of starting stainless steel production at its Pretoria steel plant.

Switzerland.—Switzerland planned to sell chromium materials from its national strategic materials stockpile.

Taiwan.—Taiwan planned to expand its stainless steel production capacity.

Turkey.—Etibank, a state-owned company, is Turkey's major chromite ore producer and only ferrochromium producer. The other major chromite ore producers include Hayri Ögelman Madencilik and Bilfer Madencilik AŞ. Etibank operated a low-carbon ferrochromium smelter at Antalya and a high-carbon ferrochromium plant at Elazığ. Chromite ore exports have declined in value from 1991-93 by over 50%, at which level the chromite mining industry operated in 1994. Chromite ore is one of Turkey's major primary mineral export income sources. Turkish chromite ore exports were affected by the change in status of the former U.S.S.R. previously described. In order to stimulate chromite ore production, Etibank planned to lease 32 chromite mines for 4 years.

United Arab Emirates.—The Department of Industry and Economy (Al Fujayrah Emirate) and Derwent Mining (Ireland) started a joint venture to exploit chromite deposits in Al Fujayrah. Derwent Mining Co. started production in 1993 producing lumpy chromite ore graded at 46% to 48% Cr_2O_3 and exported through Al Fujayrah. About 200,000 tons of chromite ore was found grading at 48% Cr_2O_3 with chromium-to-iron ratio of 3:1. Annual mine production capacity was 20,000 to 30,000 tons.

Venezuela.—Venezuela reported identifying chromite mineralization in Falcon and Aragua States. Venezuela reported 10,000 tons of chromite ore graded at 40% Cr_2O_3 in Falcon State and 38 million tons of chromite ore graded at 2.73% Cr_2O_3 in Aragua State.

Zimbabwe.—Zimbabwe reported chromite ore production of 514,000 tons in 1994, up from 252,000 tons in 1993. Zimbabwe reported 1994 ferrochromium production of 182,000 tons (153,000 tons of high-carbon ferrochromium and 29,000 tons of low-carbon ferrochromium). Zimbabwe also produced 36,000 tons of ferro-chromiumsilicon.

Two ferrochromium producers operated in Zimbabwe, Zimbabwe Mining and Smelting and Zimbabwe Alloys. Union Carbide (United States) sold its shares in Zimbabwe Mining and Smelting to a management holding company. It produces high-carbon ferrochromium at Kwekwe with an annual capacity of about 178,000 tons from six electric furnaces. Zimbabwe Alloys is a subsidiary of Anglo American (South Africa). It produces low-carbon ferrochromium with an annual capacity of about 34,000 tons and ferrochromium-silicon at Gweru. Zimbabwe Alloys started construction of a plant to recover chromium from slag (South African process), which was planned to start production in 1995. Zimbabwe Alloys operated a 17.5 megavolt-ampere furnace with an annual ferrochromiumsilicon production capacity of 15,000 tons.

Current Research and Technology

Mineral Processing and Industrial Applications.—The U.S. Geological Survey (USGS) studies the mineral potential of the United States. The USGS reported the chromite potential of the Anchorage Quadrangle, South-Central Alaska, as part of its Alaska mineral resources assessment program. The report identified the Eklutna and Wolverine complexes as containing podiform chromite deposits and reported previous studies of those deposits.[6] A statistical method was developed for estimating undiscovered chromite deposits by characterizing the number of chromite deposits in a well explored permissive area. Based on chromite deposits in Oregon and California, it was found that the relationship between the number of exposed podiform chromite deposits (N) and the area of host ultramafic rock (A) can be represented by the following: $\log_{10}(N) = -0.194 + 0.577\log_{10}(A)$.[7]

The United Nations (UN) reported on its minerals exploration program. The UN identified nine chromite exploration projects in seven countries.[8]

USBM research provides fundamental scientific and technical information essential for advancing mineral science, processing technology, and conserving and developing domestic mineral resources. This research is conducted in support of the Strategic and Critical Materials Stock Piling Act of 1946 as amended, the Defense Production Act of 1950 as amended, the Mining and Minerals Policy Act of 1970, and the National Materials and Minerals Policy, Research and Development Act of 1980. The USBM studied chromium availability, stainless steel, and chromium material flow and recycling. The USBM analyzed the availability of chromium as chromite products (ore for the chemical, foundry, metallurgical, or refractory industry) or chromium ferroalloys. A total of 873.5 million tons of in-situ chromite ore containing 202.5 million tons of chromium in 10 market economy countries was analyzed. A world network flow model was constructed to analyze world chromium supply and demand interactions.[9] The USBM studied the oxidation of type 304 stainless steel during annealing under varying ambient conditions. A Cr_2O_3 layer formed in the presence of free oxygen, while a chromium-iron spinel layer formed under oxygen-free conditions.[10] A chromium commodity flow model was developed that identifies significant losses. In 1989, the United States consumed 451,769 tons of chromium, including 99,221 tons of chromium from recycling and lost 345,347 tons of chromium to processing losses, manufacturing losses, manufacturing-downgraded scrap, prompt and obsolete scrap export, recovery losses, and recycling losses. Recovery losses, the single-largest loss accounting for nearly one-half of losses, represented chromium contained in obsolete materials never collected for recycling.[11]

The Council for Mineral Technology (Mintek) of the Republic of South Africa conducts government-sponsored, commercially sponsored, and cosponsored research and development on chromite ore and ferrochromium. Recent Mintek research has included chromite beneficiation, agglomeration, smelting, chromium recovery from slag, and stainless steel alloying. Mintek reported development of a novel jigging process that permits efficient recovery of ferrochromium from slag and a plasma process for low-carbon ferrochromium production that permits use of fine feed materials and better energy recovery. Mintek also studied ion-exchange processes for the removal of chromium from water.[12]

Environmental.—Environmental concerns about chromium have resulted in a wide variety of studies to determine chemical characteristics, natural background levels, sources of environmental emissions, movement of chromium in the environment, interaction of chromium with plants and animals, effect of chromium on plants and animals, measurement methods, and recovery technology. A broad review of many environmental factors and the role of chromium, among other metals, in the environment was published.

The EPA reported on chromium emissions from electroplating operations and chromium recovery from electroplating rinse waters.[13]

The International Chromium Development Association published industry guidelines on health, safety, and environment. The guidelines take account of extensive international changes and developments in legislation and regulation of chromium materials and is intended to help companies implement appropriate workplace practices and procedures for environmental protection.[14]

Chromium leaching behavior in soil derived from the kiln roasting and leaching of chromite ore was reported. It was found that (1) leaching was highly sensitive to pH and that the most chromium leached out at soil pH between 4 and 12 and (2) the presence of organic matter in the soil reduced the amount of chromium leached out.[15]

Outlook

The ferrochromium industry developed in close proximity to stainless steel industry. Since then, ferrochromium production capacity has moved to chromite producing areas. Further vertical integration of the chromium industry is occurring as Finland and South Africa increase its stainless steel production capacities. Two industry process trends were evolving, chromium recovery from slag in the ferrochromium industry and supply of still melted ferrochromium to stainless steel production. Both of these trends improve chromium recovery efficiency.

The outlook for chromium consumption in the United States and internationally is the same as that for stainless steel. Stainless steel is the major end use for chromium worldwide. Thus, stainless steel industry performance determines chromium industry demand worldwide.

The trend to supply chromium in the form of ferrochromium by chromite mining countries is expected to continue. With new, efficient ferrochromium production facilities and excess capacity in chromite-producing countries, both production and capacity are expected to diminish in traditional ferrochromium-producing countries, except where domestic industries are protected by quotas and tariffs. Further upward integration of the chromium industry is expected as chromite-producing countries expand ferrochromium or stainless steel production capacity.

In the 1989-90 time period, ferrochromium demand exceeded supply causing prices to increase appreciably. The industry used its profits from the price increase to expand capacity by about 15% in the 1991-92 time period. Capacity expansions took place primarily in chromite producing countries with South Africa as the major benefactor of added capacity. With a growth rate in stainless steel consumption of about 3% per year, it was estimated that about 5 years of average stainless steel demand growth to bring the ferrochromium supply-stainless steel demand back into equilibrium. The dissolution of the former U.S.S.R. in 1991 and subsequent reorganization resulted in declining chromium demand in the former U.S.S.R. without loss of chromium-material production capacity. As a result, significant quantities of chromium raw materials including chromite ore, ferrochromium, chromium chemicals, and chromium containing scrap, entered Western markets from the former U.S.S.R. The integration of the former Eastern Block with the West exacerbated the already excess production capacity in the West. During this same time period, China shifted ferroalloy production capacity to ferrochromium production.

In 1992 and 1993 significant rationalizations took place in Western chromite mining and ferrochromium industries. Not all added capacity from the 1991-92 time period could be brought into production or, if brought into production, could be fully utilized. The South African chromite ore and ferrochromium industry operated at 50% to 60% of design capacity to reduce supply in excess of world demand. Several ferrochromium producers idled furnaces or converted furnaces to ferromanganese production. The ferrochromium industry in Japan continued to be rationalized. As the Japanese ferrochromium industry continues rationalizing, the Japanese chromium industry shows greater interest in buying into the South African ferrochromium industry.

The world chromium industry in 1994 operated with supply capacity in excess of demand for most of the year. As 1994 drew to a close, increased demand for chromium ferroalloys by the Western world stainless steel industry, reduced supply owing to reduced chromite ore production in Kazakhstan, and low capacity utilization in South Africa and elsewhere resulted in chromium demand exceeding supply, and ferrochromium price started increasing. By year-end, ferrochromium demand exceeded supply. Furnaces were planned to restart ferrochromium production. Even before all of existing ferrochromium production capacity could be brought back into production, some new furnaces were planned in South Africa and chromium recovery from slag processes were planned or implemented.

It is anticipated that industrial renovation and unfulfilled consumer demand in the former U.S.S.R. could stimulate recovery in those countries and add to world demand for chromium-containing products.

A review of the world minerals industry by mineral, country, and mining company was reported. The composite world rank of chromium was found to be 10th out of 36 minerals indicating chromite to be the 10th most globally important strategic investment mineral commodity. The composite world rank is an indexed composite of five factors: output by value, population and gross domestic product, resource demand, mineral reserve base, and country investment risk.[16]

Stainless Steel.—World stainless steel production was steady in 1993-94. Former Soviet Union stainless steel production has declined since political dissolution in 1991. Western world stainless steel production has been growing since 1970 with an increased rate in the 1983-94 time period over that of the 1970-83 time period. Western world stainless steel production increased by 4% in 1993 and by 12% in 1994. In 1994, Western world stainless steel production grew in each producer sector, Europe, Japan, and the United States. European production grew about 11%, followed by Japan with a growth of 7% and the United States with a growth of 3%. Stainless steel production growth over the past two decades permitted the entry of nontraditional producers in the past decade. Other Western world stainless steel producers' capacity now rivals that of the major producers and is projected to make substantial growth in the next 2 years.

Further growth in stainless steel production was anticipated for 1995 and years immediately following. Long-term growth, strong short-term growth, near capacity utilization, and increased profitability caused stainless steel producers to plan Western world capacity expansions in 1995-96. About 800,000 tons of production capacity is expected to be added to the current U.S. capacity of 2 million tons; about 900,000 tons to current European capacity of 6 million tons; about 1.5 million tons to current other Western world capacity of 2 million tons; no additions to current Japanese capacity of 3.5 million tons.

From 1989-94, world production of chromite ore and of ferrochromium declined while world production of stainless steel, the major end use for chromium, has been steady. This trend resulted from declining ferrochromium utilization rate, which, in turn, resulted from increased use of scrap and the drawndown of ferrochromium stocks to supply stainless steel production. The trend is limited by stock supply and the supply growth of stainless steel scrap. The production of chromite ore, ferrochromium, and stainless steel all showed an upturn in 1994.

Projected stainless steel production growth is expected to reverse the decline in world chromite ore production. The projected addition of 3.2 million tons of stainless steel production capacity (current world capacity of 16 million tons), when utilized according to 1994 industry performance, should increase demand for ferrochromium by about 900,000 tons (25% of 1994 production) and demand for chromite ore by 2.3 million tons (24% of 1994 production).

Stainless steel demand is price sensitive, and an important part of stainless steel cost is nickel cost (about 70% of stainless steel requires nickel). Nickel availability and cost has been viewed as a potential limitation to increased stainless steel production. The discovery of new nickel deposits projected to produce at near one-half the cost of that of current producers mitigates this potential limitation to stainless steel production growth.

Chromium Chemicals.—Sodium bichromate demand was about 132,000 tons in 1994. Its U.S. production has been growing at about 1% per year and was expected to continue at that rate. Sodium bichromate was used to make chromic acid (64%), leather tanning (12%), chromic oxide (10%), and other end uses including wood preservatives, drilling mud additives, metal treatments, and textiles (8%). Chromic acid demand in 1994 was about 53,000 tons. Its U.S. production has been growing at about 1% per year and was expected to continue to do so. Chromic acid was used for wood preservatives (68%), metal finishing (22%), and other uses (10%) including water treatment, magnetic particles, and catalysts. Demand for wood preservatives and magnetic particles for the recording industry has been growing. World demand for chromium chemicals has been declining resulting in facility closure and capacity rationalization. Closures and rationalizations were attributed to reduced demand owing more stringent environmental regulations, general overcapacity, and collapse of the Russian economy.

A review of lead chromate pigments found that owing to restrictions on lead, use of lead chromate pigments is declining and may be nil within the next 13 years. Chrome yellow is a lead chromate pigment. The major use of chrome yellow is in coatings and plastics. As a coating, chrome yellow is used to color paint for highway center stripes. In plastics, chrome yellow is used to tint engineering resins.

EPA regulations limiting chromium releases have encouraged recycling of chromium chemicals and the use of substitutes to reduce releases. As a result, demand is expected to be reduced for many end uses.

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World Stainless Steel Statistics.

TABLE 1
SALIENT CHROMIUM STATISTICS 1/

(Thousand metric tons, contained chromium)

	1990	1991	1992	1993	1994
		WORLD PRODUCTION			
Chromite ore (mine) 2/	3,960 r/	4,020 r/	3,300 r/	2,800 r/	2,890 e/
Ferrochromium (smelter) 3/	2,150 r/	2,210 r/	2,100 r/	1,870 r/	2,000 e/
Stainless steel 4/	2,230 r/	2,260	2,170	2,100 r/	2,210 e/
		U.S. SUPPLY			
Components of U.S. supply:					
Domestic mines	--	--	--	--	--
Secondary	101 r/	96 r/	102 r/	92 r/	99
Imports:					
Chromite ore	92	65	68	84	60
Chromium ferroalloy	244	234	247	233	198
Chromium metal	7	6	5	6	7
Chromium chemicals	4	5	4	6	9
Stocks, Jan. 1:					
Government	1,260 r/	1,270 r/	1,250 r/	1,280 r/	1,210
Industry	139	126 r/	118	118	103
Total U.S. supply	1,840 r/	1,800 r/	1,800 r/	1,820 r/	1,690
Distribution of U.S. supply:					
Exports:					
Chromite ore	2	3	2	3	14
Chromium ferroalloy and metal	6 r/	7 r/	7 r/	9	8
Chromium chemicals	9 r/	9	9 r/	8 r/	12
Stocks, Dec. 31:					
Government	1,270 r/	1,250 r/	1,280 r/	1,210 r/	1,170
Industry	126	118	118	104	101
Total U.S. distribution	1,410 r/	1,390 r/	1,420 r/	1,340 r/	1,300
Apparent industry demand	432 r/	413 r/	378 r/	484 r/	390

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Calculated assuming chromite ore to average 44% Cr_2O_3 that is 68.42% chromium.

3/ Calculated assuming chromium content of ferrochromium to average 57%.

4/ Calculated assuming chromium content of stainless steel to average 17%.

TABLE 2
HISTORICAL PERFORMANCE OF THE NATIONAL DEFENSE STOCKPILE CHROMITE ORE TO FERROCHROMIUM CONVERSION PROGRAM 1/

Contract year	Ore converted (metric tons)	High- carbon ferrochromium produced (metric tons)		Cost (millions)
		Gross	Content	
1993 r/	147,000	49,800	34,100	$30.9
1994	84,100 r/	30,800 r/	21,100	19.6 r/

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits. Program completed in August 1994.

Source: Defense Logistics Agency.

TABLE 3
HISTORICAL PERFORMANCE OF THE NATIONAL DEFENSE STOCKPILE LOW-CARBON FERROCHROMIUM TO CHROMIUM METAL CONVERSION PROGRAM 1/

Time period	Low-carbon ferrochromium 2/ (metric tons)	Chromium metal (metric tons)	Cost (millions)
October 1992 - September 1993	2,890	616 r/	$5.6 r/
October 1993 - September 1994	(3/)	835	7.5

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits. Program completed in August 1994.

2/ Nonspecification grade.

3/ Stocks from the previous period were used to produce chromium metal.

Source: Defense Logistics Agency.

TABLE 4
MANUFACTURING INDUSTRY CHROMIUM 1/ RELEASE TO THE ENVIRONMENT AND TRANSFER BY MODE AND BY YEAR 2/

Mode	1991	1992
	Metric tons, contained chromium	
Releases:		
To air	442	448
To water	160	133
To underground	16	15
To land:		
Fill	2,080	1,640
Treatment	41	111
Impoundment	9,500	9,010
Other	144	176
Total release	12,400	11,500
Transfers:		
To POTW	425	428
To off-site location:		
Disposal	7,120	6,460
Recycling	30,200	43,700
Treatment	1,720	1,720
Other	199	295
Total transfer	39,700	52,600
Total releases plus transfers	52,100	64,100
	Percent	
Releases: 3/		
To air	4	4
To water	1	1
To underground	(4/)	(4/)
To land:		
Fill	17	14
Treatment	(4/)	1
Impoundment	77	78
Other	1	22
Transfers: 5/		
To POTW	1	1
To off-site location:		
Disposal	18	12
Recycling	76	83
Treatment	4	3
Other	1	1
Totals: 6/		
Total release	24	18
Total transfer	76	82

1/ Chromium contained in EPA categories chromium and chromium compounds.

2/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Releases as percent of total releases.

4/ Less than 1/2 unit.

5/ Transfers as percent of total transfers.

6/ Totals as percent of total releases plus transfers.

NOTE: Air included point and non-point (i.e. stack and fugitive) sources. POTW is publicly owned treatment works.

Source: Environmental Protection Agency, Toxic Release Inventory (May 1994).

TABLE 5
CHROMIUM 1/ RELEASED TO THE ENVIRONMENT AND TRANSFERRED BY INDUSTRY 2/

(Metric tons, contained chromium)

SIC 3/	Industry	1991	1992
20	Food products	85	41
21	Tobacco products	(4/)	(4/)
22	Textile mill products	38	65
23	Apparel	29	--
24	Lumber and wood products	91	64
25	Furniture	70	585
26	Paper and allied products	149	112
27	Printing and publishing	4	5
28	Chemical and allied products	9,960	9,460
29	Petroleum and coal	299	267
30	Rubber and plastic	183	128
31	Leather and leather products	887	967
32	Stone, clay, glass, and concrete	685	1,180
33	Primary metals	19,800	28,400
34	Fabricated metals	6,350	8,160
35	Machinery and computer equipment	7,220	7,920
36	Electrical and electronic equipment	1,070	771
37	Transportation equipment	4,750	5,460
38	Instruments	212	363
39	Miscellaneous manufacturing	58	77
	Other	196	167
	Total	52,100	64,100

1/ Chromium contained in EPA categories chromium and chromium compounds.

2/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Standard industrial classification code.

4/ Less than 1/2 unit.

Source: Environmental Protection Agency, Toxic Release Inventory (May 1994).

TABLE 6
PRINCIPAL U.S. PRODUCERS OF CHROMIUM PRODUCTS IN 1994, BY INDUSTRY

Industry and company	Plant
Metallurgical:	
Elkem AS, Elkem Metals Co.	Marietta, OH and Alloy, WV.
Macalloy Corp.	Charleston, SC.
Refractory:	
General Refractories Co.	Lehi, UT.
Harbison-Walker Refractories, a division of Dresser Industries Inc.	Hammond, IN.
National Refractories & Mining Corp.	Moss Landing, CA and Columbiana, OH.
North American Refractories Co. Ltd.	Womelsdorf, PA.
Chemical:	
American Chrome & Chemicals Inc.	Corpus Christi, TX.
Occidental Chemicals Corp.	Castle Hayne, NC.

TABLE 7
PRODUCTION, SHIPMENTS, AND STOCKS OF CHROMIUM FERROALLOYS AND METAL, AND OTHER CHROMIUM MATERIALS IN THE UNITED STATES 1/

(Metric tons)

Year	Net production: Gross weight	Net production: Chromium content	Net shipments	Producer stocks, Dec. 31
1993	63,000	44,500	61,200	5,610
1994	67,400	45,800	63,900	8,070

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

TABLE 8
CONSUMPTION OF CHROMITE AND TENOR OF ORE USED BY PRIMARY CONSUMER GROUPS IN THE UNITED STATES 1/

Year	Chemical and metallurgical industry		Refractory industry		Total	
	Gross weight (metric tons)	Average Cr_2O_3 (percentage)	Gross weight (metric tons)	Average Cr_2O_3 (percentage)	Gross weight (metric tons)	Average Cr_2O_3 (percentage)
1993	314,000	47.8	22,900	39.1	337,000	47.2
1994	302,000	47.8	20,100	40.0	322,000	47.3

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 9
U.S. CONSUMPTION OF CHROMIUM FERROALLOYS AND METAL, BY END USE 1/

(Metric tons, gross weight unless noted)

End use	Ferrochromium		Ferrochromium-silicon	Other	Total
	Low-carbon 2/	High-carbon 3/			
1993:					
Steel:					
Carbon	4,800	7,440	185	50	12,500 r/
Stainless and heat-resisting	8,450	271,000	W	100	279,000
Full-alloy	3,400	22,900	1,190	44	27,500
High-strength, low-alloy and electric	1,810	2,900	6,400	--	11,100
Tool	W	2,910	W	W	2,910
Cast irons	1,030	4,060	W	19	5,110
Superalloys	2,550	3,390	--	3,140	9,080 r/
Welding materials 4/	W	W	W	255 r/	255 r/
Other alloys 5/	1,210	275 r/	1 r/	1,180 r/	2,660 r/
Miscellaneous and unspecified	1,960	447 r/	7,710	398 r/	10,500 r/
Total 6/	25,200 r/	315,000 r/	15,500	5,180 r/ 7/	361,000 r/
Chromium content	16,900 r/	191,000	5,620	4,730 r/	218,000 r/
Stocks, December 31, 1993	3,080 r/	12,300 r/	391	656 r/ 8/	16,400 r/
1994:					
Steel:					
Carbon	4,520	6,950	199	W	11,700
Stainless and heat-resisting	8,180	252,000	14,800	41	275,000
Full-alloy	3,200	23,000	1,370	W	27,600
High-strength, low-alloy and electric	1,820	2,030	7,230	--	11,100
Tool	W	2,980	W	W	2,980
Cast irons	1,050	3,890	W	12	4,950
Superalloys	2,090	4,280	--	3,080	9,450
Welding materials 4/	15	122	--	W	137
Other alloys 5/	731	340	--	1,350	2,420
Miscellaneous and unspecified	1,580	227	985	797	3,590
Total 6/	23,200	296,000	24,600	5,280 9/	349,000
Chromium content	15,700	176,000	8,910	4,690	205,000
Stocks, December 31, 1994	1,960	12,000	527	473 10/	14,900

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Low-carbon ferrochromium contains less than 3% carbon.

3/ High-carbon ferrochromium contains 3% or more carbon.

4/ Includes structural and hard-facing welding material.

5/ Includes cutting materials and magnetic, aluminum, copper, nickel, and other alloys.

6/ Includes estimates.

7/ Includes 4,060 tons of chromium metal.

8/ Includes 481 tons of chromium metal.

9/ Includes 3,910 tons of chromium metal.

10/ Includes 292 tons of chromium metal.

TABLE 10
U.S. CONSUMER STOCKS OF CHROMITE, CHROMIUM FERROALLOYS, AND METAL, DECEMBER 31 1/

(Metric tons, gross weight)

Industry	1993	1994
Chromite:		
Chemical and metallurgical	259,000	250,000
Refractory	15,500	16,500
Total	275,000	266,000
Chromium ferroalloy and metal:		
Low-carbon ferrochromium	3,080 r/	1,960
High-carbon ferrochromium	12,300 r/	12,000
Ferrochromium-silicon	391	527
Other 2/	656 r/	473
Total	16,400 r/	14,900

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

TABLE 11
U.S. GOVERNMENT STOCKPILE YEAREND INVENTORIES AND ANNUAL DISPOSALS FOR CHROMIUM IN 1994

(Metric tons, gross weight)

Material	Inventory 1/	Disposals 2/
Chromite, metallurgical	905,000	187,000
Chromite, chemical	220,000	--
Chromite, refractory	345,000	28,100
High-carbon ferrochromium	740,000	36,000
Low-carbon ferrochromium	283,000	--
Ferrochromium-silicon	52,900	--
Chromium metal, aluminothermic	2,670	--
Chromium metal, electrolytic	5,020	--

1/ Includes specification- and nonspecification-grade material.

2/ Includes material that is intended for sale or trade.

Source: Defense Logistics Agency.

TABLE 12
TIME-VALUE 1/ RELATIONSHIPS FOR CHROMITE ORE

(Average annual value, dollars per metric ton of contained chromium)

Year	Not more than 40% chromic oxide	More than 40% but less than 46% chromic oxide	46% or more chromic oxide	Total, all grades
1993	506	204	190	196
1994	574	219	205	233

1/ Customs value per ton of chromium contained in imported material.

TABLE 13
TIME-VALUE 1/ RELATIONSHIPS FOR FERROCHROMIUM AND CHROMIUM METAL 2/

(Average annual value)

	Ferrochromium (dollars per metric ton of contained chromium)			Chromium metal (dollars per metric ton gross weight)
Year	Low-carbon 3/	High-carbon 4/	Total, all grades	
1993	1,390 r/	679	801 r/	6,140
1994	1,190	638	767	6,030

1/ Customs value per ton of chromium contained in imported material.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

3/ Carbon not more than 4%.

4/ More than 4% carbon.

TABLE 14
PRICE QUOTATIONS FOR CHROMIUM MATERIALS AT BEGINNING AND END OF 1994

Material	January	December	Year average
	Dollars per metric ton of product		
Chromite ore:			
South Africa, Republic of	50 - 60	50 - 60	55
Turkey	105 - 110	105 - 110	108
	Cents per pound of chromium		
High-carbon ferrochromium:			
Domestic: 50% to 55% chromium	52	52	52
Imported:			
50% to 55% chromium	35.5 - 38	37.5 - 38	37
60% to 65% chromium	35 - 35.5	37.5 - 38.5	36
Low-carbon:			
Domestic:			
0.05% carbon	95	95	95
0.015% carbon (Simplex)	166	166	166
Imported:			
0.05% carbon	71 - 73	81 - 83	82
0.10% carbon	53 - 55	68 - 72	67
	Cents per pound of product		
Chromium metal (domestic):			
Electrolytic	370.0	370.0	370.0
Elchrome	450.0	450.0	450.0

Source: Platt's Metals Week.

TABLE 15
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE 1/

Type	1993 Gross weight (metric tons)	1993 Value (thousands)	1994 Gross weight (metric tons)	1994 Value (thousands)	Principal destinations, 1994
Chromite ore and concentrate	10,000	$2,140	47,100	$3,550	Norway (73%); Canada (21%); Mexico (4%).
Metal and alloys:					
Chromium metal 2/	472	4,480	446	4,150	Canada (52%); Japan (30%).
Chromium ferroalloys:					
High-carbon ferrochromium 3/	10,100 4/	7,800	6,220 5/	5,260	Canada (61%); Mexico (35%).
Low-carbon ferrochromium 6/	4,390 7/	5,370	5,320 8/	6,450	Canada (58%); Mexico (13%); Netherlands (12%); Germany (8%).
Ferrochromium-silicon	800 9/	759	499 10/	554	Canada (90%); Mexico (8%).
Total ferroalloys	15,300 11/	13,900	12,000 12/	12,300	
Chemicals:					
Chromium oxides:					
Chromium trioxide	5,010	9,350	5,940	11,200	Canada (30%); Japan (15%); Republic of Korea (12%); Mexico (9%); Taiwan (8%); Australia (6%).
Other	2,040	11,500	2,450	14,700	Canada (38%); Netherlands (15%); Republic of Korea (12%); Japan (11%).
Chromium sulfates	31	71	10	45	Mexico (90%); Germany (10%).
Salts of oxometallic or peroxometallic acids:					
Zinc and lead chromate	501	4,300	938	3,150	Canada (97%); Japan (2%).
Sodium dichromate	11,700	7,800	19,600	13,000	Mexico (45%); Thailand (13%); Colombia (7%); Peru (6%).
Potassium dichromate	34	88	45	121	Canada (49%); Brazil (22%); Colombia (15%).
Other chromates, dichromates, and peroxochromates	635	1,840	470	1,750	Australia (46%); Canada (38%); United Kingdom (8%).
Pigments and preparations	2,310	9,400	1,310	6,010	Canada (28%); Israel (10%); Philippines (9%).

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Articles thereof and waste and scrap.
3/ More than 4% carbon.
4/ Contained 5,990 tons of chromium.
5/ Contained 3,700 tons of chromium.
6/ Not more than 4% carbon.
7/ Contained 2,670 tons of chromium.
8/ Contained 3,280 tons of chromium.
9/ Contained 280 tons of chromium.
10/ Contained 174 tons of chromium.
11/ Contained 8,950 tons of chromium.
12/ Contained 7,150 tons of chromium.

Source: Bureau of the Census.

TABLE 16
U.S. IMPORTS FOR CONSUMPTION OF CHROMITE ORE, BY COUNTRY 1/

	Not more than 40% Cr_2O_3 Gross weight (metric tons)	Not more than 40% Cr_2O_3 Cr_2O_3 content (metric tons)	Not more than 40% Cr_2O_3 Value (thousands)	More than 40% but less than 46% Cr_2O_3 Gross weight (metric tons)	More than 40% but less than 46% Cr_2O_3 Cr_2O_3 content (metric tons)	More than 40% but less than 46% Cr_2O_3 Value (thousands)	46% or more Cr_2O_3 Gross weight (metric tons)	46% or more Cr_2O_3 Cr_2O_3 content (metric tons)	46% or more Cr_2O_3 Value (thousands)	Total Gross weight (metric tons)	Total Cr_2O_3 content (metric tons)	Total Value (thousands)
1993:												
Philippines	6,420	2,130	$737	--	--	--	--	--	--	6,420	2,130	$737
South Africa, Republic of	--	--	--	2,310	1,060	$148	246,000	120,000	$15,600	248,000	121,000	15,800
Total	6,420	2,130	737	2,310	1,060	148	246,000	120,000	15,600	255,000	123,000	16,500
1994:												
Philippines	8,060	2,620	1,250	450	187	84	--	--	--	8,510	2,810	1,340
South Africa, Republic of	19,900	3,650	1,210	18,300	8,410	1,200	155,000	72,300	10,200	193,000	84,400	12,600
Total	27,900	6,270	2,470	18,700	8,600	1,290	155,000	72,300	10,200	201,000	87,200	13,900

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 17
U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY 1/

Country	Low-carbon (not more than 3% carbon)			Medium-carbon (more than 3% carbon but not more than 4% carbon)			High-carbon (more than 4% carbon)			Total (all grades)		
	Gross weight (metric tons)	Chromium content (metric tons)	Value (thousands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thousands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thousands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thousands)
1993:												
Albania	--	--	--	--	--	--	7,180	4,320	$2,960	7,180	4,320	$2,960
China	--	--	--	--	--	--	3,710	2,310	1,830	3,710	2,310	1,830
Croatia	--	--	--	--	--	--	21,300	13,400	8,740	21,300	13,400	8,740
Finland	--	--	--	--	--	--	38,200	20,400	15,400	38,200	20,400	15,400
France	--	--	--	--	--	--	6	4	6	6	4	6
Germany	10,200	7,370	$18,400	--	--	--	210	140	172	10,400	7,510	18,600
India	--	--	--	--	--	--	13,600	7,970	5,640	13,600	7,970	5,640
Japan	288	208	866	--	--	--	124	83	243	412	291	1,110
Kazakhstan	5,350	2,750	3,280	--	--	--	30,400	18,900	11,600	35,700	21,700	14,900
Netherlands	--	--	--	--	--	--	25	17	25	25	17	25
Poland	--	--	--	--	--	--	32	22	20	32	22	20
Russia	22,600	13,200	15,300	--	--	--	16,700	10,900	7,230	39,300	24,100	22,500
South Africa, Republic of	5,220	2,890	3,660	--	--	--	74,800	37,400	25,800	80,000	40,300	29,400
Turkey	5,950	4,180	4,920	--	--	--	84,700	52,300	32,900	90,700	56,400	37,800
Ukraine	4,070	2,770	2,040	3,260	2,260	$1,240	10,800	7,440	3,500	18,100	12,500	6,780
United Kingdom	38	26	51	123	83	84	410	249	277	570	358	412
Zimbabwe	5,730	3,560	4,850	--	--	--	22,100	14,400	12,800	27,800	17,900	17,600
Total	59,400	37,000	53,400	3,380	2,350	1,330	324,000	190,000	129,000	387,000	229,000	184,000
1994:												
Albania	--	--	--	--	--	--	7,690	4,800	3,250	7,690	4,800	3,250
China	3,010	1,970	2,770	--	--	--	370	222	146	3,380	2,190	2,920
Croatia	--	--	--	--	--	--	21,200	13,100	7,820	21,200	13,100	7,820
Estonia	--	--	--	--	--	--	2,000	1,350	804	2,000	1,350	804
Finland	--	--	--	--	--	--	13,800	7,670	5,680	13,800	7,670	5,680
France	60	41	75	--	--	--	3	2	4	63	43	78
Germany	4,420	3,160	9,060	--	--	--	53	36	33	4,470	3,200	9,090
India	--	--	--	--	--	--	7,250	4,460	3,040	7,250	4,460	3,040
Japan	580	400	1,580	--	--	--	86	57	169	666	456	1,750
Kazakhstan	9,100	6,380	5,650	1,800	1,210	613	18,300	11,800	6,970	29,200	19,300	13,200
Macedonia	324	220	269	--	--	--	--	--	--	324	220	269
Mexico	--	--	--	397	281	179	--	--	--	397	281	179
Poland	--	--	--	--	--	--	386	263	243	386	263	243
Russia	30,700	20,800	23,700	--	--	--	25,700	16,700	11,000	56,500	37,500	34,700
Slovakia	2,060	1,450	934	--	--	--	--	--	--	2,060	1,450	934
South Africa, Republic of	10,800	5,940	5,010	2,600	1,310	954	67,200	34,100	22,400	80,600	41,300	28,400
Sweden	--	--	--	--	--	--	120	80	65	120	80	65
Turkey	1,720	1,190	1,520	30	19	21	62,500	38,800	24,000	64,300	40,000	25,500
Ukraine	303	222	451	--	--	--	--	--	--	303	222	451
United Kingdom	17	13	30	--	--	--	198	133	230	215	146	260
Former U.S.S.R.	--	--	--	--	--	--	3,320	2,290	1,060	3,320	2,290	1,060
Zimbabwe	1,310	694	946	--	--	--	18,000	11,500	7,070	19,300	12,200	8,020
Total	64,500	42,500	52,000	4,830	2,820	1,770	248,000	147,000	94,000	317,000	193,000	148,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 18
U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE 1/

Type	1993 Gross weight (metric tons)	1993 Value (thousands)	1994 Gross weight (metric tons)	1994 Value (thousands)	Principal sources, 1994
			METALS AND ALLOYS		
Chromium metal:					
Waste and scrap	437	$2,000	366	$1,730	China (93%); Russia (6%).
Other than waste and scrap	5,730	35,900	6,160	37,600	China (30%); France (22%); United Kingdom (18%); Russia (15%)
Ferrochromium-silicon	8,750 2/	6,180	15,100 3/	7,790	Russia (42%); China (27%); Zimbabwe (26%).
			CHEMICALS		
Chromium oxides and hydroxides:					
Chromium trioxide	362	1,280	2,540	4,820	Kazakhstan (39%); Germany (36%); China (11%); Japan (7%).
Other	3,090	10,300	5,740	13,900	Kazakhstan (22%); Germany (19%); Canada (18%); Japan (13%); Netherlands (12%).
Sulfates of chromium	162	97	241	166	Turkey (50%); Mexico (22%); Germany (17%).
Salts of oxometallic or peroxometallic acids:					
Chromates of lead and zinc	252	772	281	861	Japan (44%); Canada (22%); Norway (17%).
Sodium dichromate	10,300	5,860	10,500	5,920	United Kingdom (89%); Argentina (4%); Canada (4%).
Potassium dichromate	522	754	396	693	United Kingdom (44%); Russia (33%); Mexico (13%).
Other chromates and dichromates; peroxochromates	668	1,590	708	1,570	United Kingdom (88%); France (10%).
Chromium carbide	124	1,120	151	1,320	United Kingdom (46%); Japan (44%).
			PIGMENTS AND PREPARATIONS BASED ON CHROMIUM		
Chrome yellow	3,610	8,000	5,080	11,400	Canada (62%); Hungary (13%); Mexico (12%).
Molybdenum orange	680	2,020	616	1,870	Canada (94%).
Zinc yellow	246	554	218	435	Norway (67%); Poland (27%).
Other	446	2,110	481	2,730	France (32%); Germany (29%); Canada (19%).

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Contained 3,310 tons of chromium.

3/ Contained 5,260 tons of chromium.

Source: Bureau of the Census.

TABLE 19
AVAILABILITY OF CHROMITE AND CHROMIUM FERROALLOYS FROM 10 MARKET ECONOMY COUNTRIES

Chromium materials	Quantity available (million metric tons, gross weight)	Cost 1/ (dollars per metric ton) Weighted average	Cost 1/ (dollars per metric ton) Range
Chromite:			
Chemical grade	64.3	53	$35 - $174
Foundry sand grade	16.4	49	39 - 83
Metallurgical grade:			
Primary product	145.4	101	42 - 705
Secondary product	35.6	54	33 - 117
Subtotal	181.0	92	33 - 705
Refractory grade	26.8	87	54 - 180
Total	288.5		
Chromium ferroalloys:			
Ferrochromium:			
High-carbon ferrochromium	74.3	473	417 - 1,286
Low-carbon ferrochromium	3.9	937	635 - 1,309
Ferrochromium-silicon	2.0	737	578 - 814
Total	80.2		

1/ Cost of production for zero percent discounted cash-flow rate of return in Jan. 1989 dollars per metric ton, gross weight, of product f.o.b. at port of export.

Source: U.S. Bureau of Mines, Minerals Availability system cost analysis.

TABLE 20
PRINCIPAL WORLD CHROMITE PRODUCERS, 1994

Country 1/	Company
Albania	Albchrome (Government owned).
Brazil	Bayer AG (Germany)
	Coitezeiro Mineração S.A.
	Cia. de Ferro-Ligas da Bahia S.A.
	Cia. de Mineração Serra de Jacobina S.A.
	Mineração Vale do Jacurici S.A.
	Industria e Comércio de Minérios S.A.
	Invituruí Mineração S.A.
	Magnesita S.A.
	Piunhiense Mineração Ltda.
	Rada Mineração Ltda.
Finland	Outokumpu Oy (Government owned).
India	Ferro Alloys Corp. Ltd.
	Mysore Mineral Ltd.
	Orissa Mining Corp. Ltd. (Government owned).
	Tata Iron and Steel Co. Ltd.
Kazakhstan	Donskoy Ore Dressing Complex.
Philippines	Acoje Mining Co. Inc.
	Benguet Corp.
	Philchrome Mining Corp.
Russia	Saranov Complex.
South Africa, Republic of 2/	Anglovaal Ltd.
	Lavino (Pty.) Ltd.
	African Mining and Trust Co. Ltd.
	Zeerust Chrome Mine Ltd.
	Rustenburg Minerals Development Co. (Pty.) Ltd.
	Bayer (Germany).
	Chrome Chemicals SA (Pty.) Ltd.
	Canadian Gold S.A. (Pty.) Ltd.
	Goudini Chrome (Pty.) Ltd.
	Chromecorp Technology (Pty.) Ltd.
	Chroombronne (Pty.) Ltd.
	Genmin Ltd.
	Samancor Chrome Ltd.
	Batlhako Mining Ltd.
	Henry Gould (Pty.) Ltd.
	Millsell Chrome Mines (Pty.) Ltd.
	Montrose Mine.
	Groothoek Section.
	Jagdlust Section.
	Montrose Section.
	Mooinooi Mine.
	Tweefontein Mine.
	Waterkloof Mine.
	Winterveld Chrome Mines Ltd.
	Hernic Chrome
	Hernic Mining (Pty.) Ltd.
	Johannesburg Consolidated Investment Co.
	Consolidated Metallurgical Industries Ltd.
	Purity Chrome (Pty.) Ltd.
	Lebowa Development Corp. Ltd.
	Dilokong Chrome Mine (Pty.) Ltd.
	National Manganese Mines (Pty.) Ltd.
	Buffelsfontein Chrome Mine.
	Tolgate Group Holding (Pty.) Ltd.
	Pilanesberg Chrome (Pty.) Ltd.
	Vereeniging Refractories Ltd.
	Marico Chrome Corp. Ltd.
	Bophuthatswana Chrome Co. (Pty.) Ltd.
Turkey	Etibank (Government owned).
	Bursa Toros Kromlari AS.
	Egemetal Madencilik AS.
	Sitki Kocman Mines.
	Turk Maadin Sirketi AS.
	Hayri Ogelman Madencilik AS.
Zimbabwe	Zimbabwe Alloys Ltd.
	Zimbabwe Mining and Smelting Co. (Pvt.) Ltd.

1/ Other chromite-producing countries included Burma, China, Cuba, Egypt, Indonesia, Iran, Japan, Macedonia, Madagascar, Morocco, Oman, Pakistan, and Sudan.

2/ Includes Bophuthatswana.

TABLE 21
PRINCIPAL WORLD FERROCHROMIUM PRODUCERS, 1994

Country 1/	Company
Albania	Albchrome (Government owned).
Brazil	Cia. de Ferro-Ligas da Bahia S.A.
China	Chongqing Ferroalloy Works (Government owned).
	Emei Ferroalloy Works (Government owned).
	Hanzhong Ferroalloy Works (Government owned).
	Hengshan Iron and Steel Works (Government owned).
	Hunan Ferroalloy Works Government owned).
	Jiangyin Ferroalloy Works (Government owned).
	Jilin Ferroalloy Works (Government owned).
	Jinzhou Ferroalloy Works (Government owned).
	Liaoyang Ferroalloy Works (Government owned).
	Nanjing Ferroalloy Works (Government owned).
	Shanghai Ferroalloy Works (Government owned).
	Xibei Ferroalloy Works (Government owned).
Croatia	Tvornica Karbida i Ferolegura Dalmacija.
Finland	Outokumpu Oy (Government owned).
Germany	Gesellschaft für Elektrometallurgie mbH
	Elektrowerk Weisweiler GmbH.
India	Deepak Ferro-Alloys Ltd.
	Ferro-Alloys Corp. Ltd.
	Indian Metals & Ferroalloys Ltd.
	Indian Charge Chrome Ltd.
	Industrial Development Corp.
	Tata Iron and Steel Co. Ltd.
	OMC Alloys Ltd.
	Visvesvaraya Iron & Steel Ltd. (State owned)
Italy	Acciaierie e Ferriere Lombarde Falck SpA.
	Ferroleghe SpA.
Japan	Japan Metals and Chemicals Co. Ltd.
	Nippon Denko Co. Ltd.
	NKK Corp.
	Pacific Metals Co. Ltd.
	Showa Denko K.K.
Kazakhstan	Aktubinsk Ferroalloy Works.
	Yermakovsky Ferroalloy Works.
Norway	Elkem Rana.
Philippines	Ferrochrome Philippines Inc.
	Integrated Chrome Corp.
	Metro Alloys.
Russia	Chelyabinsk Electrometallurgical Works.
	Klyuchevsk Ferroalloy Works.
	Metroalloys.
	Serovsk Ferroalloy Works.
Slovenia	Tovarna Dusika Ruse.
South Africa, Republic of	Anglovaal Ltd.
	Feralloys Ltd.
	Chromecorp Technology (Pty.) Ltd.
	Johannesburg Consolidated Investment Co. Ltd.
	Consolidated Metallurgical Industries Ltd.
	Lydenburg Works.
	Rustenburg Works.
	Purity Ferrochrome (Pty.) Ltd.
	Genmin Ltd.
	Samancor Ltd.
	Batlhako Ferrochrome Ltd.
	Ferrometals Ltd.
	Middelburg Ferrochrome (Pty.) Ltd.
	Pamiet Ferrochrom (Pty.) Ltd.
	Tubatse Ferrochrome Division
Sweden	Vargõn Alloy AB.
Turkey	Etibank (Government owned).
United States	Elkem Metals Co.
	Macalloy Corp.
Zimbabwe	Zimbabwe Alloys Ltd.
	Zimbabwe Mining and Smelting Co. (Pvt.) Ltd.

1/ Other ferrochromium-producing countries include Chile, Mexico, Poland, Romania, Spain and Taiwan.

TABLE 22
CHROMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country 3/	1990	1991	1992	1993	1994 e/
Albania	950,000 r/	587,000 r/	322,000 r/	282,000 r/	223,000 4/
Brazil 5/	263,000 r/	340,000	449,000 r/	308,000 r/	360,000 4/
Burma e/	1,000	1,000	6,200	1,000 r/	1,000
China e/	25,000	25,000	25,000	54,000 r/	50,000
Cuba e/	50,000	50,000	50,000	50,000	50,000
Egypt	399	649	600 e/	600 e/	600
Finland	504,000	473,000	499,000	511,000 r/	573,000 4/
Greece 6/	35,400	37,200	4,000 r/ e/	3,000 r/ e/	4,000
India	1,050,000 r/	940,000 r/	1,150,000 r/	1,000,000 r/	909,000 4/
Indonesia e/	8,000	1,950 4/	2,000	2,500	2,500
Iran 7/	77,200	90,100	130,000	130,000 r/ e/	129,000 4/
Japan e/	8,080 4/	8,000	8,000	7,000	7,000
Kazakhstan	XX	XX	3,500,000 r/	2,900,000	2,020,000 4/
Macedonia e/ 8/	XX	XX	6,000	5,000	5,000
Madagascar 7/	151,000 r/	149,000 r/	161,000 r/	144,000 r/	90,200 4/
Morocco	300	500	500	500 e/	500
New Caledonia	6,220	--	8,170 r/	-- e/	--
Oman	--	--	1,760	10,000 e/	6,200 4/
Pakistan	18,200	31,500	22,900	22,200 r/	23,000
Philippines	183,000 r/	191,000	65,700 r/	68,400 r/	68,900 4/
Russia e/	XX	XX	121,000	121,000 r/	143,000 4/
South Africa, Republic of 9/	4,620,000	5,100,000	3,360,000	2,830,000 r/	3,590,000 4/
Sudan e/	12,500 4/	10,000	10,000	10,000	10,000
Turkey 10/	836,000	940,000 e/	531,000	570,000 r/ e/	790,000
U.S.S.R. 11/	3,800,000	3,800,000 e/	XX	XX	XX
United Arab Emirates e/	--	--	1,000 r/	20,000 r/	25,000
Yugoslavia 8/ 12/	10,800	6,000 e/	XX	XX	XX
Zimbabwe	573,000	564,000	522,000	252,000 r/	517,000 4/
Total	13,200,000 r/	13,300,000	11,000,000	9,300,000	9,600,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 29, 1995.

3/ Figures for all countries represent marketable output unless otherwise noted.

4/ Reported figure.

5/ Average Cr_2O_3 content was as follows: 1990—39.2% (revised); 1991—41.9% (revised); 1992—44.1% (revised); 1993—41.0% (revised); and 1994—41.3%.

6/ Direct-shipping ore plus concentrate.

7/ Concentrate.

8/ All production in Yugoslavia from 1990-91 came from Macedonia.

9/ Includes production by Bophuthatswana.

10/ Salable product: direct-shipping lump ore plus concentrate.

11/ Dissolved in Dec. 1991.

12/ Dissolved in Apr. 1992.

TABLE 23
FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Albania	24,000	25,000	22,000 r/	36,000 r/	34,000
Brazil 3/	83,800	82,200	91,100 r/	83,900 r/	77,100 4/
Chile	1,870	2,510	2,110 r/	680 r/	1,580 4/
China e/	340,000 r/	380,000 r/	410,000 r/	372,000 r/	370,000
Croatia	XX	XX	56,500	27,300	32,000
Czechoslovakia 3/ 5/	37,500 r/	41,200 r/	52,500 r/	XX	XX
Finland	157,000	190,000	187,000	218,000	229,000 4/
France e/	25,000	23,100	6,690 4/	–	–
Germany:					
Eastern states	21,000 e/	XX	XX	XX	XX
Western states	37,500 e/	XX	XX	XX	XX
Total	58,500 e/	38,300 r/	26,500	16,400	17,300 4/
Greece	30,300	10,500 e/	–	–	–
India 6/	169,000	229,000 r/	257,000	235,000 r/	251,000 4/
Iran 7/	–	–	–	–	5,000
Italy	53,000	47,200	60,300	53,500	22,700
Japan 3/	304,000	279,000	276,000	211,000 r/	203,000 4/
Kazakhstan	XX	XX	400,000 e/	328,000 r/	185,000
Macedonia	XX	XX	3,960	4,380	3,160 4/
Mexico	275	72	70 e/	– r/	–
Norway	60,000	83,000	102,000	80,000	120,000 4/
Philippines	55,700 r/	23,700	27,400	11,900 r/	16,200 4/
Poland	13,700	1,930	35,300	38,400	7,000
Romania	20,600	20,400	6,980	3,910	3,900 4/
Russia	XX	XX	400,000	256,000 r/	266,000 4/
Slovakia 3/ 4/	XX	XX	XX	50,600 r/	48,500 4/
Slovenia	XX	XX	17,100	9,000	12,600
South Africa, Republic of 8/ 9/	1,020,000	1,150,000 r/	771,000 r/	834,000 r/	1,100,000 4/
Spain e/	15,000	6,000	–	2,390 4/	2,000
Sweden	118,000	121,000	133,000	128,000	134,000 4/
Turkey	62,000 r/	84,700	85,800	90,000	97,600 4/
U.S.S.R. e/ 10/	700,000	700,000	XX	XX	XX
United States 11/	109,000	68,300	60,900	63,000	67,400 4/
Yugoslavia 12/	82,700	91,000	XX	XX	XX
Zimbabwe 3/	222,000	187,000	191,000	130,000 r/ e/	190,000
Total	3,760,000 r/	3,880,000 r/	3,680,000 r/	3,280,000 r/	3,500,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 29, 1995.

3/ Includes high- and low-carbon ferrochromium.

4/ Reported figure.

5/ Czechoslovakia was dissolved on Dec. 31, 1992. All production in Czechoslovakia from 1990-92 came from Slovakia.

6/ Includes ferrochrome and charge chrome.

7/ Production began in 1994. Plant capacity is estimated at 7,000 tons per day.

8/ Includes high- and low-carbon ferrochromium and ferrochromium-silicon.

9/ Includes production from Bophuthatswana.

10/ Dissolved in Dec. 1991.

11/ Includes high- and low-carbon ferrochromium, ferrochromium-silicon, chromium metal, and other chromium materials.

12/ Dissolved in Apr. 1992.

TABLE 24
WORLD CHROMIUM ANNUAL PRODUCTION CAPACITY OF CHROMITE ORE, FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL IN 1994 1/

(Thousand metric tons, contained chromium)

	Ore	Ferro-chromium	Metal	Chemicals	Stainless steel
Albania	150	32	--	--	--
Argentina	--	--	--	6	NA
Austria	--	--	--	--	12
Bangladesh	--	--	--	--	3
Belgium	--	--	--	--	75
Brazil	135	89	(2/)	12	37
Burma	(2/)	--	--	--	--
Canada	--	--	--	--	32
Chile	--	2	--	--	--
China	13	200	5	16	68
Croatia	--	42	--	--	--
Cuba	14	--	--	--	11
Czech Republic	--	--	--	--	NA
Egypt	1	--	--	--	--
Finland	211	115	--	--	73
France	--	--	5	--	156
Germany	--	76	1	20	255
Greece	21	--	--	--	--
India	309	167	(2/)	5	45
Indonesia	20	--	--	--	--
Iran	34	4	--	2	--
Italy	--	64	--	--	146
Japan	3	178	1	21	595
Kazakhstan	1,100	330	--	42	--
Korea, North	--	32	--	--	--
Korea, Republic of	--	--	--	--	94
Macedonia	3	7	--	5	--
Madagascar	21	--	--	--	--
Mexico	--	2	--	--	NA
Norway	--	88	--	--	--
Oman	4	--	--	--	--
Pakistan	10	--	--	3	--
Philippines	60	60	--	--	--
Poland	--	16	--	7	NA
Romania	--	26	--	5	NA
Russia	40	233	16	63	330
Slovakia	--	30	--	--	--
Slovenia	--	8	--	--	NA
South Africa, Republic of	1,600	794	--	--	30
Spain	--	--	--	--	112
Sudan	2	--	--	--	--
Sweden	--	97	--	--	105
Taiwan	--	1	--	--	28
Thailand	(2/)	--	--	--	--
Turkey	300	103	--	10	54
Ukraine	--	--	--	--	33
United Arab Emirates	8	--	--	--	--
United Kingdom	--	--	5	68	94
United States	--	83	3	55	330
Zimbabwe	170	133	--	--	--
Total	4,230	3,010	39	340	2,720

NA Not available.

1/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

FIGURE 1
IMPORTED HIGH-CARBON FERROCHROMIUM PRICES IN 1994

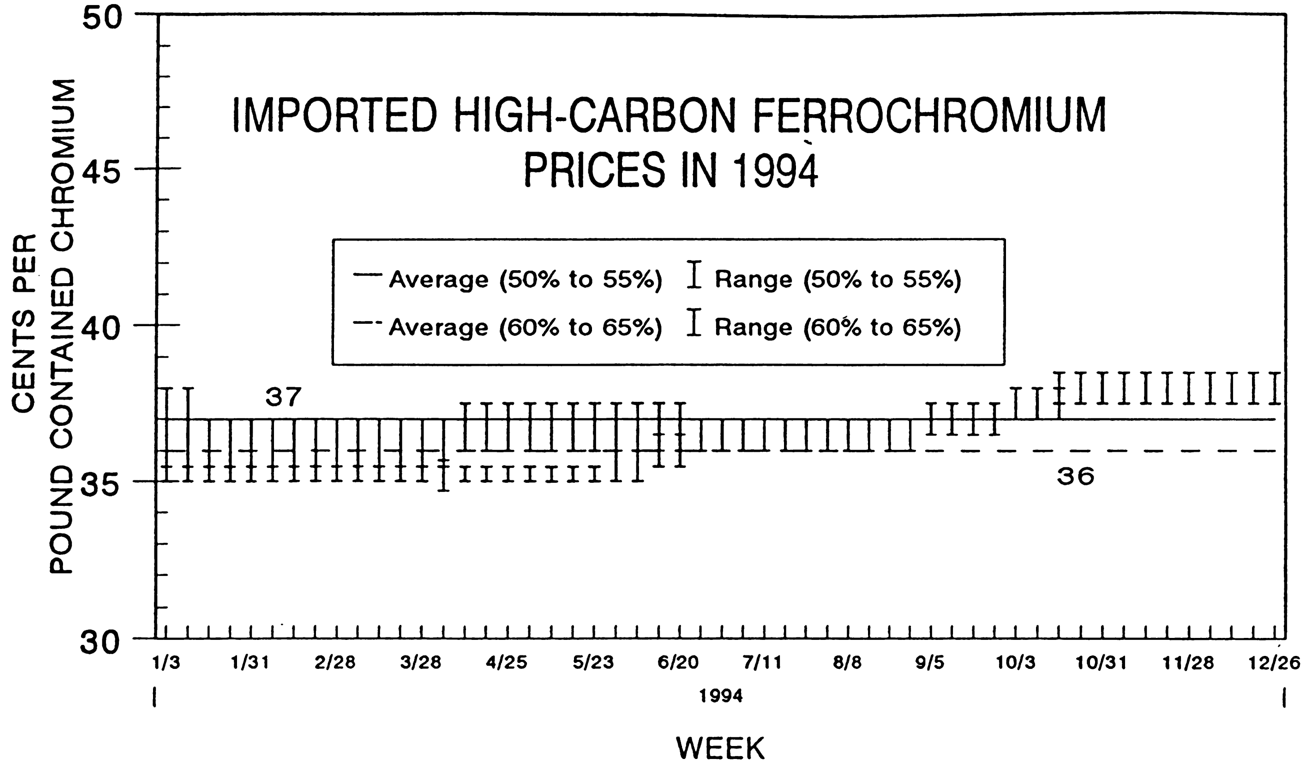
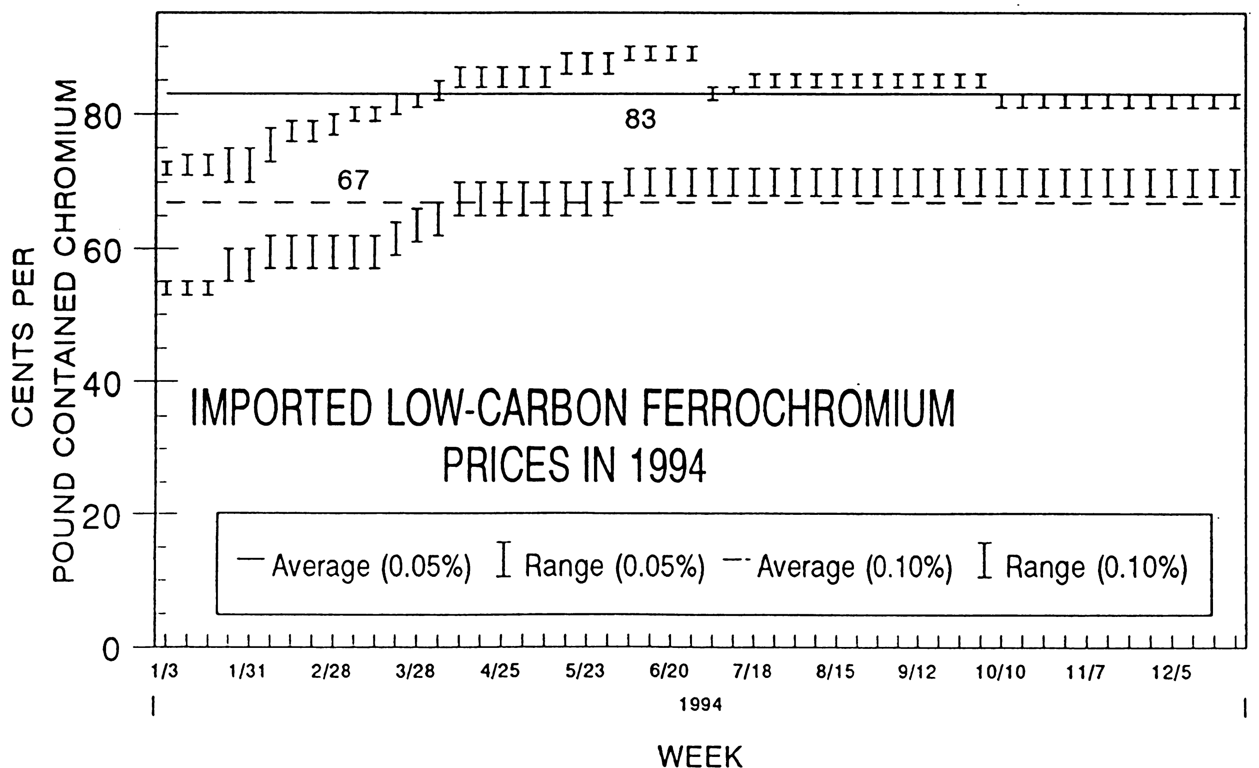


FIGURE 2
IMPORTED LOW-CARBON FERROCHROMIUM WEEKLY PRICE RANGE AND TIME-AVERAGED ANNUAL PRICE IN 1994



Source: Metals Week.

CLAYS

By Robert L. Virta

The amount of clay sold or used by domestic producers increased to 42.2 million metric tons valued at $1.6 billion. Production of ball clay, bentonite, common clay, and fuller's earth increased in 1994. Common clays accounted for 61% of the tonnage. Kaolin accounted for 64% of the value of clays produced in 1994. Imports decreased to 36,000 tons valued at $14.9 million. Exports increased to 4.62 million tons valued at $739 million. (*See table 1.*)

Domestic production data for clays are developed by the U.S. Bureau of Mines (USBM) from one voluntary survey of U.S. operations. Of the 594 operations covered by the survey, 420 responded, representing 71% of the total clay and shale production sold or used shown in table 1. Production data for the nonrespondents were estimated from reported prior-year production levels adjusted by trends in the industry and other guidelines.

Legislation and Government Programs

Clay mining has an environmental impact because of the disturbance to the land. Overburden is moved and clays are removed, leaving a depression or pit. State laws usually require leveling or recontouring of the disturbed area and planting trees or grasses to prevent or minimize erosion. For processing, the impoundment of slimes and dust control are usually required. The rules for disposal of coarse tailings are similar to or included with those laws governing reclamation of the mined area.

Production

An estimated 293 companies operating 983 clay pits or mines reported production in 1994; of these, 90 companies, most with multiple operations, accounted for approximately 25% of the tonnage and 44% of the value for all types of clay produced and sold or used. Clay production was reported in most States and Puerto Rico except Alaska, Delaware, Hawaii, Idaho, Rhode Island, Vermont, Wisconsin, and the District of Columbia.

The 10 leading producer States, in descending order, were Georgia, North Carolina, Wyoming, Alabama, Texas, Ohio, California, South Carolina, Missouri, and Tennessee. (*See table 2.*)

Most of the clay is mined by open pit methods. Less than 1% of U.S. clay output was from underground mines in 1994. Most of the underground production was in Pennsylvania, Ohio, and West Virginia, where the clays are mainly underclays associated with coal and suitable for refractory uses.

Ball Clay.—The ball clay industry was small, with 6 producers operating 26 mines in 5 States in 1994. Three of the producers were large, diversified firms with widespread foreign and domestic mineral interests.

Production of domestic ball clay increased to 1.05 million tons valued at $45.6 million. Tennessee supplied 63% of the Nation's output, followed by, in descending order of production, Texas, Kentucky, Indiana, Mississippi, and Ohio. Production increased in all States except Kentucky. Water-slurried ball clay was produced in Kentucky and Tennessee. Air-float ball clay was produced in Indiana, Kentucky, Mississippi, and Tennessee. (*See table 3.*)

Bentonite.—Twenty-two firms producing bentonite operated 68 mines in 14 States. Four producers were large, diversified firms with international mineral operations; three of the firms had interests in other types of clay in the United States.

The quantity and value of all varieties of bentonite sold or used increased to 3.29 million tons valued at $136 million. Mississippi led all States in the production of nonswelling bentonite, followed by California, Alabama, Utah, Texas, Arizona, Oregon, Colorado, Nevada, and Montana. Production increased in Arizona, Colorado, Texas, and Utah and was unchanged in California, Montana, and Oregon.

Wyoming led all States in the production of swelling bentonite, followed by Montana, California, Oregon, Texas, Nevada, and Tennessee. Production increased in California, Montana, Nevada, Oregon, and Wyoming and was unchanged in Texas. (*See table 5.*)

Smith International purchased 64% of the shares of M-I Drilling Fluids Co. from Dresser Industries Inc. The sale was made after Dresser Industries purchased Baroid Drilling Fluids Inc. earlier in the year.[1] Colloid Environmental Technologies Co. (CETCO), a subsidiary or American Colloid Co., purchased a facility for manufacturing bentonite liners from Mary Ann Industries. CETCO announced plans to build facilities for producing bentonite liners in Wyoming and England.[2] CETCO also purchased Hydron Inc. Hydron specializes in water treatment technologies and held a patent on a method for using bentonite clay flocculants to treat waste streams.[3]

Common Clay and Shale.—Two hundred eighteen firms producing common clay and shale in 1994 were manufacturers of structural clay products such as clay pipe, sewer pipe, lightweight aggregates, and cement. Most companies mined the clays used in making products. Less than 10% of the total output usually is sold. Some companies owned and operated several clay pits and plants to cover a large market area. The economic radius for shipment of common clay or shale products was usually 320 kilometers or less. The high cost of transport promoted the development of local ownership companies, or in the case of a large firm, the ownership and operation of several strategically located pits and associated fabricating plants.

Domestic sales or use of common clay and shale increased to 25.9 million tons valued at $142 million. The major producing States were North Carolina, Texas, Alabama, Ohio, Georgia, California, Michigan, South Carolina, Missouri, and Arkansas, in descending order of tonnage. The largest increases in production were observed in Indiana, North Carolina, and South Carolina. The largest decreases were observed in California and Michigan. (*See table 7.*)

Fire Clay.—Fireclay producers were mostly refractories manufacturers that used the clays in firebrick and other refractories. Seventy-two mines were operated in 1994 by 20 firms in 12 States.

Fire clay sold or used by domestic producers decreased to 458,000 tons valued at $11.7 million. Missouri, was the leading producing State, followed by Ohio, Alabama, Arkansas, Georgia, Washington, New Mexico, Colorado, and Montana. The largest increase in production was in Missouri and Washington, while Georgia experienced the largest decline in production. (*See table 9.*)

Fuller's Earth.—Eighteen companies produced fuller's earth from 32 mines in 11 States. Seven of the mines were in the attapulgite-fuller's earth areas of Florida and Georgia; these two States accounted for most of the domestic attapulgite production. Most producers were small, independent firms, but three were large, diversified corporations with international mineral interests.

Production of fuller's earth increased to 2.64 million tons valued at $244 million. Production of attapulgite-type fuller's earth was 901,000 tons valued at $125 million in 1994. Over one-half of this production came from Georgia, followed by Florida, and Nevada. Production in Nevada was of sepiolite-type fuller's earth. Production increased slightly in Georgia and Nevada.

Production of montmorillonite-type fuller's earth was 1.74 million tons valued at $119 million. Mississippi led all States in production, followed by Illinois, Missouri, California, Florida, Tennessee, Georgia, Virginia, Kansas, and Texas, in decreasing order of production. The greatest increases in production were in Missouri and Tennessee. Slight increases were observed in the other States. (*See table 11.*)

Engelhard Corp. announced plans to purchase portions of Floridan Co.'s specialty minerals operations in Florida. Floridan mines and processes attapulgite for agricultural products, caulks, coatings, paints, and pet litter.[4] American Colloid Co. indicated that it would increase its capacity at Paris, TN, for its agricultural carriers and scoopable cat litter products. Capacity will be 60,000 tons for agricultural carriers and 40,000 tons for cat litter.[5]

Kaolin.—Thirty-four firms operated 134 kaolin mines in 14 States. In 1994, three large, diversified firms accounted for about 60% of total domestic kaolin output. The kaolin operations were concentrated in Georgia.

Domestic production of kaolin was 8.77 million tons valued at $1.02 million. Georgia was the largest kaolin producer, followed by South Carolina, Alabama, Arkansas, California, Nevada, North Carolina, Texas, Florida, Minnesota, Pennsylvania, and Colorado, in decreasing order of production. Production increased in Colorado, Georgia, Pennsylvania, and Texas. Production remained the same or declined in the other producing States. (*See table 13.*)

Approximately 48% of the kaolin produced was water-washed; followed by calcined, 17%; delaminated, 15%; air-floated, 14%; and unprocessed, 6%. (*See table 14.*) These percentages were essentially unchanged from 1993.

Production of high-temperature calcined kaolin declined in 1994 and production of low-temperature calcined kaolin increased. (*See table 15.*)

Production in Georgia was 7.57 million tons valued at $962 million. Over one-half of the production was water-washed kaolin. (*See table 16.*) Production in South Carolina decreased slightly. The actual decrease is not as large as shown in Table 18. The tonnage for unprocessed kaolin was concealed to avoid revealing company proprietary data. (*See table 18.*) Unprocessed kaolin was sold or used in most States in what may be considered to be common clay applications (i.e., brick, cement, pottery, etc.).

Theile Kaolin Co. contracted for the installation of a high-capacity superconducting separator in Wrens, GA. The company also began an expansion program that will increase production capacity to more the 1.5 million tons.[6] Engelhard Corp. installed a new calciner to meet increasing demands for calcined kaolin by the paper industry.[7] M & M Clays Co. began operating a slurry plant. The slurried kaolin will be sold for ceramics applications.[8]

Consumption

Ball Clay.—The principal domestic ball clay markets were floor and wall tile, pottery, and sanitaryware. (*See table 4.*) Consumption increased in 1994. The largest increases were in sales to fillers and extenders, floor and wall tile, and sanitaryware applications. Most of the increase reported for filler and extender applications was accounted for by animal feed applications. Increased sales to the floor and wall tile and sanitaryware industries were attributed largely to improved conditions in the building and construction industries. Sales for other applications remained essentially unchanged.

Bentonite.—Major markets for bentonite were drilling mud, foundry sand, iron ore pelletizing, and pet waste absorbents. Consumption increased for drilling muds, civil engineering and sealing applications, iron ore pelletizing, and pet waste absorbents. (*See table 6.*)

Sales of swelling bentonite for pet waste absorbents continued its rapid growth due to the marketing success of clumping kitty litters. Sales to the drilling mud industry were reported to have increased significantly in 1994. This is inconsistent with industry trends. Actual consumption is estimated to be approximately 500,000 tons. There was a slight decline in the sales of bentonite for foundry sand applications while sales for use in pelletizing iron ore increased. An estimated 100,000 tons of the bentonite reported under domestic consumption was exported to the Canadian iron ore industry. (*See table 6.*) Sales of bentonite for use in civil engineering, sealing, and waterproofing increased in response to stricter environmental regulation of landfill and other waste sites.

With regard to the sales of swelling versus nonswelling bentonite, most of the data was concealed to avoid disclosing company proprietary data. Over one-half of the bentonite sold for pet waste, oil, and grease absorbent applications was swelling bentonite; for animal feeds, 82% was swelling bentonite. The bulk of the bentonite sold for ceramics was nonswelling and approximately 99% of the bentonite sold for drilling mud applications was swelling bentonite. Over one-half of the bentonite sold for foundry sand applications was swelling bentonite and for filtering, clarifying, and decolorizing applications, over one-half was nonswelling bentonite. Bentonite sold for pelletizing iron ore was exclusively swelling bentonite. Most of the refractory-grade bentonite was of the swelling variety and over one-half of the bentonite used for civil engineering, waterproofing and sealing was swelling bentonite.

The major uses for swelling bentonite were drilling mud, foundry sand, iron ore pelletizing, pet waste absorbent, and civil engineering and sealing, in decreasing order of consumption. The major uses for nonswelling bentonite were foundry sand, pet waste absorbent, oil and grease absorbent, waterproofing and sealing, and pottery, in decreasing order of consumption.

Common Clay and Shale.—Common clay was used most frequently in the manufacture of heavy clay products, including (1) building brick; flue linings, sewer pipe, drain tile, structural tile, and terra cotta; (2) portland cement clinker; and (3) lightweight aggregate. Sales for civil engineering and sealing applications increased significantly because of the increased emphasis on controlling effluents from landfill and other waste sites. Sales of common clay and shale for brick and other heavy clay products and lightweight aggregate increased in response to improved conditions in the construction and housing industries. Producers reported decreased sales to the portland cement industry. Sales on the order of 7.6 to 7.8 million tons for cement production would be more consistent with industry trends. (*See table 8.*)

Fire Clay.—Fire clays were used in refractory products such as firebrick and block, grogs and calcines, high-alumina brick and specialties, saggers, refractory mortars and mixes, and ramming and gunning mixes. Fire clays also were used to produce such items as lightweight aggregates, portland cement, and pottery.

Consumption of fire clay decreased slightly as reported by domestic producers. Major markets for fireclay were firebrick, followed by grogs and calcines, high alumina brick, mortar and cement, portland cement, pottery, and foundry sand. (*See table 10.*) The largest reported decrease was in firebrick applications, from 236,000 tons in 1993 to 160,000 in 1994. The 236,000 tons reported by producers was inconsistent with historical trends concerning the sales of fireclay for firebrick production and the use of firebrick in refractory applications. Sales of 200,000 tons or less would have been expected in 1993, making the decline in consumption between 1993 and 1994 less than is shown in table 10. The tonnage sold for brick and portland cement production increased in 1994, consistent with trends in the building industry.

Fuller's Earth.—The major uses for attapulgite-type and montmorillonite-type of the fuller's earths were as pet waste absorbents; pesticide carriers; and oil and grease absorbents, in decreasing order of consumption. (*See table 12.*) Consumption of both types of fuller's earth increased in 1994 with sales of montmorillonite-type fuller's earth increasing more than those for the attapulgite-type fuller's earth.

The largest reported increases in consumption were for pesticide and pet waste applications. The increase in pet waste applications is consistent with trends in sales of clay-type pet litter. Reported sales of attapulgite-type and montmorillonite-type fuller's earth for pesticide applications increased in 1994, following the trend for the past few years. Consumption of fuller's earth in animal feed decreased. All of the decrease in animal feed sales was absorbed by the montmorillonite-type fuller's earth category. Sales of attapulgite for drilling mud applications and filtering, clarifying, and decolorizing oils and greases declined in 1994. The decrease in sales in the fertilizer market was absorbed almost entirely by the montmorillonite-type fuller's earth. The large increase in the filler and extenders category was accounted for by increased sales of montmorillonite-type fuller's earth for asphalt tile applications. (*See table 12.*)

With regard to the sales of attapulgite-type fuller's earth versus montmorillonite-type fuller's earth, most of the data was concealed to avoid disclosing company proprietary data. Approximately 135,000 tons of attapulgite was sold for oil and grease absorbents and 304,000 tons was sold for pet waste absorbents. Only attapulgite was sold for animal feed and drilling mud applications. Over 50% of the fuller's earth sold for fertilizer applications was attapulgite. Attapulgite was used to decolorize or clarify mineral oils and greases while montmorillonite was used to decolorize or clarify animal oils. Over one-half of the fuller's earth used as pesticide carriers was montmorillonite. Montmorillonite also was used in asphalt tile, electrical porcelain, and refractories.

The major uses for montmorillonite-type fuller's earth was pet waste absorbents, pesticide carriers, oil and grease absorbents, and asphalt tile, in decreasing order of consumption. The major uses for attapulgite was in pet waste absorbents, oil and grease absorbents, pesticide carriers, and fertilizer carriers, in decreasing order of consumption.

Kaolin.—Producers reported a slight decrease in sales in 1994. The major markets were in paper coating, paper filler, high alumina refractory brick, fiber glass, grogs, paint, rubber, and catalysts, in decreasing order of consumption. (*See table 20.*) The largest increase in consumption was for high alumina specialties. The increase resulted because producers shifted a large portion of their sales from grogs to high alumina specialties. A large increase also was reported for sales of kaolin to the paper coating and filler applications, corresponding to improvements in the paper market. Sales to the portland cement market decreased despite a strong building industry. The decline affected only a few producers. Only small changes were reported in other markets.

Major domestic markets for kaolin from Georgia were paper coating, paper filling, refractories, fiberglass, paint, and catalysts, in decreasing order of consumption. Sales to the fiber glass, high alumina specialties, paint, and paper markets increased. Sales to the adhesive, grog, and rubber markets decreased. Other markets were relatively unchanged. The major market for kaolin from South Carolina was in rubber. Other significant markets were fiber glass, catalyst, adhesives, and roofing granules, in decreasing order of consumption. Sales for asphalt emulsion, firebrick, and catalyst applications decreased while sales for roofing granules increased. No major changes were reported for other end use categories. (*See tables 17 and 19.*)

Absorbent Uses.—Absorbent uses for clays accounted for about 2.44 million tons. Pet waste absorbents accounted for approximately 82% of absorbent consumption, followed by oil and grease absorbents (15%), and miscellaneous absorbent applications (3%). Demand for absorbents increased in 1994 corresponding to the growth in the pet litter market. Fuller's earth was the principal clay used for absorbent purposes, followed by bentonite. (*See tables 6 and 12.*) Small amounts of ball clay and kaolin also were used for absorbent applications.

Ceramics.—All varieties of clays were used in ceramics. Total demand for clay in the manufacture of ceramics, ranging from china to sanitaryware to tile to roofing granules, was approximately 1.67 million tons. The largest ceramics market for clays was in ceramic floor and wall tile, followed by sanitaryware, catalysts, pottery, and roofing granules. Ball clay accounted for 38% of the clay used in ceramics, followed by kaolin (31%) and common clay and shale (25%). Small amounts of bentonite, fire clay, and fuller's earth also were used in the manufacture of ceramics. With regard to individual ceramics markets, ball clay dominated the glazing, pottery, and sanitaryware markets. Common clay and shale was the predominant clay used in roofing granules, abrasives, and quarry tile. Kaolin dominated the catalyst, crockery, and fine china markets. Common clay and shale and ball clay were the predominant clays used in floor and wall tile manufacture. (*See tables 4, 8, 10, and 20.*)

Construction.—Common clays and shales were used to manufacture a wide variety of construction materials such as expanded aggregates, hydraulic cement, and structural clay products.

Expanded Clay and Shale.—Approximately 3.75 million tons of clays was used in the production of lightweight aggregate. Nearly all of the clay used to manufacture lightweight aggregate was common clay and shale. Lightweight aggregates were used in concrete block, structural concrete, and highway surfacing, in decreasing order of consumption. (*See tables 8 and 21.*)

Hydraulic Cement.—Clays provide the alumina and silica required to manufacture hydraulic cements. Common clays, kaolin, fire clay, fuller's earth, and bentonite, in decreasing order of consumption, were used in cement products. Approximately 98% of the clay consumed by the cement industry was common clay and shale. (*See tables 8 and 20.*)

Structural Clay Products.—Approximately 14.3 million tons of clays was used in the manufacture of structural clay products such as building brick, drain tile, flue linings, roofing tile, sewer pipe, and terra cotta. Common and face brick accounted for 93% of this total. Other markets, in decreasing order of consumption, were terra cotta, sewer pipe, flue linings, structural tile, flower pots, drain tile, and roofing tile. Approximately 98% of the clay used in these applications was common clay and shale. (*See tables 8, 20, and 22.*)

The Bureau of the Census reported shipments of building and face brick to be 7.15 billion bricks valued at $1.09 billion, an increase from 1993. Shipments of clay floor and wall tile increased to almost 56 million square meters valued at $724 million. Shipments of vitrified clay and sewer pipe fittings increased to 125,000 tons valued at $32.6 million.

Drilling Mud.—Reported demand for clays in drilling muds was 609,000 tons. This exceeds industry trends, which would place consumption at about 500,000 tons. Swelling-type bentonite remained the principal clay used in drilling mud mixes, although fuller's earth, used mostly in saltwater drilling techniques, also was used. (*See tables 6 and 12.*)

Filler.— Approximately 5.08 million tons of clays was used as fillers and extenders. Clays are used as binders, extenders, and fillers in a wide variety of products, ranging from adhesives to flooring products to paint to paper to rubber. Paper coating and filling accounted for 70% of the filler and extender market consumption, followed by pesticides (6%), paint (5%), rubber (5%), animal feed (4%), and asphalt emulsion (2%).

Kaolin accounted for approximately 83% of the clay used in filler and extender applications, followed by fuller's earth (10%), ball clay (3%), bentonite (2%), common clay and shale (2%), and minor amounts of fire clay. (*See tables 4, 6, 12, and 20.*) For specific end uses, common clay and shale dominated in the wallboard market. Fuller's earth was predominant in asphalt tile and pesticide applications. Kaolin dominated the adhesive, paint, paper, and rubber markets.

Glass.—Approximately 364,000 tons of kaolin was used in fiberglass. A small amount of bentonite was used as a raw material feed for manufacturing mineral wool. (*See table 20.*)

Iron Ore Pelletizing.—Demand increased to 564,000 tons in 1994. Almost all of the clay used in pelletizing was bentonite. (*See table 6.*) Small amounts of common clay and shale also were used.

Paper Products.—Kaolin accounted for essentially all of the clay used for paper coating (2.63 million tons) and 99% of the clay used for paper filling (929,000 tons). (*See table 20.*) Small amounts of ball clay were used in paper-filling applications and a small amount of bentonite was used for paper coating.

Refractories.—Approximately 2.28 million tons of clays was used for the manufacture of refractories. The largest markets were foundry sand (32%), high alumina specialties (23%), firebrick (15%), and grogs and calcines (13%). Ball clay, bentonite, common clay and shale, fire clay, and kaolin accounted for 2%, 33%, 13%, 14%, and 38%, respectively, of the refractories markets. Ball clay, common clay and shale, and fire clay were the most commonly used clays for firebrick; bentonite for foundry sand; and kaolin for grogs, calcines, and high alumina specialties. (*See tables 4, 6, 8, 10, and 20.*)

Prices

Ball Clay.—The average value for ball clay reported by domestic producers was $43.43 per ton. The average value of imported ball clay was $336.12. The average value of exported ball clay was $42.84 per ton.

Bentonite.—The average value reported by domestic producers for nonswelling bentonite was $50.68 per ton. The average value for swelling bentonite was $39.57 per ton. The average value for all types of bentonite was $41.34 per ton. The average value of imported bentonite was $381.46 per ton. The average value of exported bentonite was $90.49 per ton.

Common Clay and Shale.—The average value for all common clay and shale produced in the United States and Puerto Rico was $5.48 per ton. The average value of clay and shale used in lightweight aggregate was $10.43 per ton.

Fire Clay.—The average value for fire clay reported by domestic producers was $25.55 per ton. The average of imported fire clay was $450.49 per ton. The average value of exported fire clay was $108.00 per ton.

Fuller's Earth.—The average value of attapulgite-fuller's earth reported by domestic producers was $138.76 per ton. The average value of montmorillonite-fuller's earth was $68.54 per ton. The average average value of all types of fuller's earth was $92.51 per ton. The average value of imported fuller's earth was $45.14 per ton. The average value of exported fuller's earth was $132.72 per ton.

Kaolin.—The average value of kaolin was $116.31 per ton for all kaolin grades. The average value for air-float kaolin was $56.69 per ton; for high-temperature calcined kaolin,

$172.26; for low-temperature calcined kaolin, $167.38; for all types of calcined kaolin, $172.19 per ton; for delaminated kaolin, $123.44 per ton; for water-washed kaolin, $122.64 per ton; and for unprocessed kaolin, $23.47 per ton. The average value of the imported kaolin was $373.15 per ton. The average value of exported kaolin was $167.30 per ton.

The average value for low-temperature calcined kaolin decreased significantly in 1994. The reason was that a large percentage of the low-temperature calcined kaolin was used in chemical manufacture rather than pigment applications. The average value for low-temperature calcined kaolin used for pigment applications was greater than that reported in 1993, which was $334.39 per ton.

Foreign Trade

Ball Clay.—Ball clay exports increased to 81,000 tons valued at $3.47 million, according to the Bureau of the Census. Shipments were made to 20 countries. (*See table 23.*) Domestic ball clay producers reported that 116,085 tons of ball clay was exported in 1994. The exports were used mainly for floor and wall tile production and sanitaryware production. Other major uses are asphalt emulsions, china, dinnerware, and filler and extender applications.

Discrepancies were observed between the export tonnage reported by the Bureau of the Census and that reported by producers. A major reason is that the producers may not control the final sale and movement of the clays, as when a mineral broker is involved. Some clays originally destined for export may be sold domestically and vice-versa without the knowledge of the producer.

Imports in 1994 were 836 tons of ball clay valued at $281,000. (*See table 24.*)

Bentonite.—Bentonite exports increased to 768,000 tons valued at $69.5 million. Bentonite was exported to 63 countries. Domestic bentonite producers reported exports of 431,241 tons. This discrepancy is partially explained by the inclusion of an estimated 100,000 tons of bentonite for Canadian iron ore pelletizing under domestic sales. Also see the discussion under ball clay concerning discrepancies between export data reported by producers and those reported by the Bureau of the Census. The largest market for exported bentonite was foundry sand. Other major markets were drilling mud, grogs and calcines, and paint. (*See tables 6 and 23.*)

Bentonite imports consisted mainly of untreated bentonite clay and chemically or artificially activated materials. Imports of untreated bentonite were 2,052 tons valued at $782,000. Imports of chemically activated material decreased to 12,900 tons valued at $7.78 million. (*See table 24.*)

Fire Clay.—Exports of fire clay were 225,000 tons valued at $24.3 million. Fire clay was exported to 38 countries. According to the Bureau of the Census, 1,030 tons valued at $464,000 was imported in 1994. (*See tables 23 and 24.*)

Fuller's Earth.—Approximately 74,000 tons of fuller's earth valued at $9.82 million, were exported. Fuller's earth was exported to 44 countries. Domestic producers reported more than 161,000 tons exports in 1994. Discrepencies between producers' and Bureau of the Census reports for exports are similar to the situation with ball clay. Also, some of the exports reported by producers may have been classified as pet litter by the Bureau of the Census rather than as fuller's earth. (*See table 12.*) The major market for exported fuller's earth was pet waste absorbents. Other markets were ceramic tile, foundry sand, cosmetics, oil and grease absorbents, paint, and pesticide carriers. Approximately 1,440 tons of decolorizing and fuller's earth valued at $65 million were imported in 1994. (*See tables 12, 23, and 24.*)

Kaolin.—The Bureau of the Census reported that 3.18 million tons of kaolin, valued at $532 million were exported in 1994. Kaolin was exported to 67 countries. Producers reported exports of 2.27 million tons. Discrepencies between producers' and Bureau of the Census reports for exports are similar to the situation with ball clay. Major export markets reported by producers were paper coating (76%) and paper filling (13%). (*See tables 20 and 23.*) Other major export markets for exported kaolin were in paint and rubber.

Kaolin imports increased to 10,800 tons valued at $4.03 million. (*See table 24.*)

World Review

World production of bentonite was 7.58 million tons, fuller's earth production was 3.82 million tons, and kaolin production was 30.4 million tons. (*See tables 25, 26, and 27, respectively.*)

Australia.—Comalco Ltd. continued its expansion of its processing plants near Weipa. The company planned to expand capacity of coating grade kaolin to 200,000 tons per year.

Belgium.—Caulim da Amazonia SA installed a slurry plant at its kaolin handling facilities in Antwerp.

Brazil.—Progress on the kaolin project at Rio Capim Quimica was slowed because of challenges being made to the environmental impact studies. The project is a cooperative effort between Companhia Vale do Rio Doce and Caulim da Amazonia.

The joint venture between Mendes Junior and Amberger Kaolinwerke Eduard Kick GmbH obtained permission to develop a kaolin mine in Rio Capim. Work began at the mine site and equipment for the mill was ordered. The companies anticipate an initial production rate of 500,000 tons per year.

France.—Groupe Mineral Harwanne purchased the mines and mills of Kaolins du Finistere SA. Kaolins du Finistere was owned by ECC International and supplied kaolin to the ceramic and glass markets.

Japan.—Engelhard Corp. opened a new distribution center for its paper grade kaolin. The distribution will be near paper mills and give the company increased storage space and more flexibility in its product packaging.

Mexico.—Kentucky-Tennessee Clay Co. opened a processing plant near Monterrey. The $6.5 million plant will produce ball clay and kaolin slurries for the ceramics industries.

Outlook

U.S. clay demand between 1982 and 1994 has rebounded slowly from 32 million tons to 43 millon tons. Fueling the increase are the generally improved building and construction industry (for brick, cement, ceramics, etc.), growing paper industry (paper coating and filler), growth in the pet litter market (pet waste absorbents), and concerns over seepage from landfills and waste dumps (civil engineering and sealing applications). Most of these markets can be expected to grow over the next few years. The possible exception is with the building construction industry which is predicted to temporarily level off in 1995.

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[2] Chemical Marketing Reporter. American Colloid Units Expand Bentonite Product Output. V. 246, No. 10, Sept. 5, 1994, p. 15.

[3] ———. American Colloid Grows. V. 245, No. 25, June 20, 1994, p. 7.

[4] ———. Engelhard Acquires Attapulgite Producer. V. 245, No. 24, June 13, 1994, p. 13.

[5] Industrial Minerals (London). American Colloid Expands Paris Facility. No. 320, May 1994, p. 21.

[6] Mining Magazine. Cryofilter HGMS for Georgia Kaolin. Jan. 1994, p. 38.
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[7] Engelhard Corporation 1994 Annual Review.

[8] Ceramic Industry. Slurry Plant Opens in Georgia. V. 143, No. 6, Nov. 1994, p. 13.

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Industrial Minerals and Rocks, 5th ed., AIME, 1983.

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TABLE 1
SALIENT U.S. CLAY STATISTICS 1/ 2/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
Domestic clays sold or used by producers:					
Quantity	42,900	41,000	40,200	40,700 r/	42,200
Value	$1,620,000	$1,460,000	$1,470,000	$1,470,000 r/	$1,600,000
Exports:					
Quantity	4,120	4,000	4,160	4,150	4,620
Value	$584,000	$590,000	$663,000	$670,000	$739,000
Imports for consumption:					
Quantity	30	35	41	39	36
Value	$12,000	$13,200	$15,500	$17,600	$14,900

r/ Revised.

1/ Excludes Puerto Rico.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

TABLE 2
CLAYS SOLD OR USED BY PRODUCERS IN THE UNITED STATES 1/ 2/ IN 1994, BY STATE

(Thousand metric tons and thousand dollars)

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total	Total value
Alabama	--	W	2,010	72	--	199	2,280	25,400
Arizona	--	W	98	--	--	--	98	452
Arkansas	--	--	883	W	--	W	883	2,440
California	--	144	1,420	--	W	W	1,570	20,600
Colorado	--	1	288	(3/)	--	2	292	2,320
Connecticut	--	--	W	--	--	--	W	W
Florida	--	--	W	--	395	35	430	55,000
Georgia	--	--	1,710	W	680	7,570	9,960	1,060,000
Illinois	--	--	494	--	W	--	494	1,170
Indiana	W	--	774	--	--	--	774	2,540
Iowa	--	--	384	--	--	--	384	1,520
Kansas	--	--	556	--	W	--	556	2,150
Kentucky	W	--	820	--	--	--	820	3,460
Louisiana	--	--	371	--	--	--	371	3,280
Maine	--	--	W	--	--	--	W	W
Maryland	--	--	293	--	--	--	293	946
Massachusetts	--	--	W	--	--	--	W	W
Michigan	--	--	1,150	--	--	--	1,150	3,370
Minnesota	--	--	W	--	--	W	W	W
Mississippi	W	139	645	--	410	--	1,190	40,500
Missouri	--	--	1,040	213	W	--	1,250	7,910
Montana	--	W	28	W	--	--	28	W
Nebraska	--	--	206	--	--	--	206	867
Nevada	--	7	--	--	W	W	7	2,860
New Hampshire	--	--	3	--	--	--	3	16
New Jersey	--	--	W	--	--	--	W	W
New Mexico	--	--	127	W	--	--	127	269
New York	--	--	507	--	--	--	507	9,270
North Carolina	--	--	2,530	--	--	W	2,530	12,500
North Dakota	--	--	59	--	--	--	59	W
Ohio	W	--	1,940	142	--	--	2,080	12,500
Oklahoma	--	--	771	--	--	--	771	3,910
Oregon	--	25	215	--	--	--	241	1,560
Pennsylvania	--	--	797	--	--	14	811	4,040
South Carolina	--	--	1,130	--	--	388 4/	1,520	30,400 4/
South Dakota	--	--	W	--	--	--	W	W
Tennessee	665	W	W	--	W	--	665	28,600
Texas	W	W	2,190	--	W	W	2,190	13,700
Utah	--	W	243	--	--	W	243	3,410
Virginia	--	--	870	--	W	--	870	3,250
Washington	--	--	246	W	--	--	246	1,140
West Virginia	--	--	138	--	--	--	138	291
Wyoming	--	2,530	W	--	--	--	2,530	91,300
Undistributed	385	449	1,010	32	1,150	563	3,600	148,000
Total	1,050	3,290	25,900	458	2,640	8,770	42,200	1,600,000

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."

1/ Excludes Puerto Rico.

2/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Less than 1/2 unit.

4/ Unprocessed Kaolin withheld to avoid disclosing company proprietary data; included in "Undistributed."

TABLE 3
BALL CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

	Airfloat		Water-slurried		Unprocessed		Total	
State	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1993 e/								
Tennessee	232	12,200	138	5,860	236	7,660	607	25,700
Other 2/	127 r/	6,860 r/	--	--	176	5,950	305 r/	12,800 r/
Total	360 r/	19,000 r/	138	5,860	412	13,600	911 r/	38,500 r/
1994								
Tennessee	263	14,100	163	6,810	239	7,660	665	28,600
Other 2/	210	10,800	(3/)	(3/)	175	6,250	385	17,000
Total	473	24,900	163	6,810	413	13,900	1,050	45,600

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes Indiana, Kentucky, Mississippi, Ohio, and Texas.

3/ Included with "Unprocessed."

TABLE 4
BALL CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1993	1994
Filler, extenders, and binders 2/	138,000 r/	166,000
Floor and wall tile	205,000	270,000
Miscellaneous ceramics 3/	39,800	36,100
Pottery	116,000	117,000
Refractories 4/	42,000	43,100
Sanitaryware	185,000	217,000
Miscellaneous 5/	69,200 r/	73,300
Exports 6/	116,000	127,000
Total	911,000 r/	1,050,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes adhesives, animal feed, asphalt emulsions, asphalt tile, cosmetics, gypsum products, paper filling, pesticides, paint, plastics, rubber, wallboard, and other filler, extenders and binders.

3/ Includes electrical porcelain, fine china/dinnerware, glazes, and miscellaneous ceramics.

4/ Includes firebrick, blocks, and shape, high-alumina brick and specialties, and kiln furniture.

5/ Includes absorbents, brick (common), flue lining, glazes, waterproofing seals, drilling mud, and other uses unknown.

6/ Includes ceramics and glass, fillers, extenders and binders, floor and wall tile, refractories, and other uses unknown.

TABLE 5
BENTONITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	Nonswelling		Swelling		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1993						
California	W	W	W	W	140	13,100
Colorado	(2/)	6	--	--	(2/)	6
Mississippi	152	5,310	--	--	152	5,310
Nevada	W	W	W	W	16	3,430
Oregon	W	W	W	W	24	1,110
Wyoming	--	--	2,180 r/	63,300 r/	2,180 r/	63,300 r/
Other 3/	321	17,600	212	16,000	353 r/	16,000
Total	473	22,900	2,400 r/	79,300 r/	2,870 r/	102,000 r/
1994						
California	W	W	W	W	144	13,700
Colorado	1	12	--	--	1	12
Mississippi	139	4,980	--	--	139	4,980
Nevada	W	W	W	W	7	2,860
Oregon	W	W	W	W	25	1,150
Wyoming	--	--	2,530	91,300	2,530	91,300
Other 3/	375	21,100	250	18,900	449	22,300
Total	515	26,100	2,780	110,000	3,290	136,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Includes Alabama, Arizona, Montana, Tennessee, Texas, Utah, Virginia (1993), and items indicated by symbol W.

TABLE 6
BENTONITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1993	1994
Domestic:		
Absorbents:		
Pet waste absorbents	302,000	455,000
Other absorbents	66,400	91,000
Adhesives	W	W
Animal feed	78,300 r/	96,900
Ceramics (except refractories) 2/	24,100 r/	W
Drilling mud	476,000 r/	586,000
Filler and extender applications 3/	30,600 r/	30,000
Filtering, clarifying, decolorizing:		
Animal oils, minerals oils and greases, and vegetable oils	13,000 r/	W
Foundry sand	733,000 r/	712,000
Pelletizing (iron ore)	466,000 r/	509,000
Miscellaneous refractories and kiln furniture 4/	58,000 r/	32,200
Miscellaneous 5/	2,340 r/	55,400
Waterproofing and sealing	213,000 r/	287,000
Total	2,460,000 r/	2,850,000
Exports:		
Drilling mud	90,400	34,200
Foundry sand	243,000 r/	321,000
Other 6/	72,000 r/	80,500
Total	405,000 r/	436,000
Grand total	2,870,000 r/	3,290,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes catalysts (oil-refinings), mineral wools and insulation, floor and wall tile, and pottery.

3/ Includes medical, pharmaceutical, and cosmetics, paint, paper coating, pesticides and related products, plastics, asphalt emulsions, ink, and miscellaneous fillers and extenders applications.

4/ Includes firebrick, blocks, and shapes, plugs, taps, wads, and miscellaneous refractories.

5/ Includes waterproofing seals, chemical manufacturing, oil well sealings, filtering and clarifying oils, heavy clay products, lightweight aggregate, desiccants, and other uses unknown.

6/ Includes absorbents, ceramics, waterproofing and sealing, fillers and extenders, filtering and clarifying oils, and pelletizing refactories.

TABLE 7
COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	1993		1994 2/	
	Quantity	Value	Quantity	Value
Alabama	2,110	15,700	2,010	18,900
Arkansas	796	2,360	883	2,440
California	1,690	8,430	1,420	6,910
Georgia	1,680	11,600	1,710	11,200
Indiana	600	2,540	774	2,540
Kansas	513	1,970	556	2,150
Kentucky	768	3,060	820	3,460
Michigan	1,230	4,850	1,150	3,370
Mississippi	537	4,480	594	5,960
Missouri	976	3,820	1,040	4,630
New York	508	9,250	507	9,270
North Carolina	2,380	11,200	2,530	12,500
Ohio	2,020	7,890	1,940	7,950
Oklahoma	613	2,940	771	3,910
Pennsylvania	754	3,120	797	3,230
South Carolina	1,010	4,500	1,130	4,670
Texas	2,180	17,400	2,190	13,700
Virginia	775	2,950	870	3,250
Other 3/	4,150 r/	18,900 r/	4,260	21,600
Total	25,300	137,000	25,900	142,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not to totals shown.

2/ Excludes Puerto Rico.

3/ Includes all other States except; Alaska, Delaware, Hawaii, Idado, Nevada, Rhode Island, Vermont, and Wisconsin.

TABLE 8
COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1993	1994 2/
Ceramics and glass 3/	159,000	136,000
Civil engineering and sealing	84,200	177,000
Floor and wall tile:		
Ceramic	274,000	283,000
Other 4/	100,000	45,100
Heavy clay products:		
Brick, extruded	10,900,000	11,400,000
Brick, other	1,450,000	1,620,000
Drain tile and sewer pipe	142,000	140,000
Flowerpots	35,700	35,800
Flue linings	55,300	60,600
Structural tile	35,000	37,100
Other 5/	582,000	710,000
Lightweight aggregate:		
Concrete block	2,210,000	2,400,000
Highway surfacing	243,000	247,000
Structural concrete	787,000	801,000
Miscellaneous 6/	286,000	305,000
Portland and other cements	7,540,000	6,920,000
Refractories 7/	153,000	303,000
Miscellaneous 8/	231,000	311,000
Total	25,300,000	25,900,000

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes Puerto Rico.

3/ Includes crockery/earthenware, pottery, roofing granules, and abrasives.

4/ Includes quarry tile and miscellaneous floor and wall tiles.

5/ Includes roofing tile, sewer pipe, terra cotta, and miscellaneous clay products.

6/ Includes miscellaneous lightweight aggregates.

7/ Includes firebrick, blocks and shapes, mortar and cement, and miscellaneous refractories.

8/ Includes asphalt emulsions, wall board, pelletizing (iron ore), exports, and other uses unknown.

TABLE 9
FIRE CLAY 1/ 2/ SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE

(Thousand metric tons and thousand dollars)

	1993		1994	
State	Quantity	Value	Quantity	Value
Alabama	71	2,860	72	3,190
Missouri	208	3,920	213	3,280
Ohio	142	4,140	142	4,550
Other 3/	37	621	31	655
Total	459	11,500	458	11,700

1/ Refractory uses only.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes Arkansas, Colorado, Georgia, Montana, New Jersey (1993), New Mexico, and Washington.

TABLE 10
FIRE CLAY SOLD OR USED BY PRODUCERS 1/ IN THE UNITED STATES, BY USE

(Metric tons)

Use	1993	1994
Ceramics and glass 2/	19,100	W
Heavy clay products and lightweight aggregates 3/	43,700	41,400
Refractories:		
Firebrick, block and shapes	236,000	160,000
Other refractories 4/	130,000	155,000
Miscellaneous	31,100	102,000
Exports	W	W
Total	459,000	458,000

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes pottery.

3/ Includes portland cement, terra cotta, and other uses unknown.

4/ Includes foundry sand, grogs and calcines, high-alumina brick and specialties, morter and cement, plug, tap and wad, and other uses unknown.

TABLE 11
FULLER'S EARTH SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

	Attapulgite		Montmorillonite		Total	
State	Quantity	Value	Quantity	Value	Quantity	Value
1993						
Florida	407	52,700	(2/)	(2/)	407	52,700
Georgia	641	79,100	(2/)	(2/)	641	79,100
Southern States 3/	--	--	472	34,200	472	34,200
Western States 4/	(5/)	(5/)	963	63,700	963	63,700
Total	1,050	132,000	1,440	97,800	2,480	230,000
1994						
Florida	395	51,500	(2/)	(2/)	395	51,500
Georgia	680	83,700	(2/)	(2/)	680	83,700
Southern States 3/	--	--	570	41,000	570	41,000
Western States 4/	(5/)	(5/)	993	67,900	993	67,900
Total	1,080	135,000	1,560	109,000	2,640	244,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Included with "Attapulgite."

3/ Includes Mississippi, Tennessee, and Virginia.

4/ Includes California, Illinois, Kansas, Missouri, Nevada, Texas, and Utah (1993).

5/ Included with "Montmorillonite."

TABLE 12
FULLER'S EARTH SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1993	1994
Absorbents:		
Oil and grease absorbent	259,000	296,000
Pet waste absorbent	1,470,000	1,550,000
Miscellaneous absorbent	42,700	W
Animal feed	90,500	17,800
Drilling mud	30,100	22,600
Fertilizers	89,700	59,600
Fillers, extenders, binders 2/	70,800	119,000
Filtering, clarifying, decolorizing:		
Animal, mineral, and vegetable oils, and greases	35,100	12,700
Pesticides and related products	191,000	305,000
Miscellaneous 3/	68,000	89,600
Exports 4/	138,000	161,000
Total	2,480,000	2,640,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes adhesives, asphalt tiles, gypsum products, medical, pharmaceutical and cosmetics, paint, plastics, asphalt emulsions, and other uses unknown.

3/ Includes catalysts (oil-refining), electrical porcelain, roofing granules, chemical manufacturing, portland cement, lightweight aggregates, refractories, and other uses unknown.

4/ Includes absorbents, fillers, extenders and binders, floor and wall tiles, refractories, and other uses unknown.

TABLE 13
KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	1993		1994	
	Quantity	Value	Quantity	Value
Arkansas	230	W	W	W
California	104 r/	4,780 r/	W	W
Florida	W	W	35	3,470
Georgia	7,340 r/	903,000 r/	7,570	962,000
South Carolina	534	26,800	388 2/	25,700 2/
Other 3/	619	21,800	779	27,100
Total	8,830 r/	957,000 r/	8,770	1,020,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Unprocessed Kaolin withheld to avoid disclosing company proprietary data; included in "Other."

3/ Includes Alabama, Colorado, Minnesota, Nevada, North Carolina, Pennsylvania, Texas, and items indicated by symbol W.

TABLE 14
KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY KIND 1/

(Thousand metric tons and thousand dollars)

Kind	1993		1994	
	Quantity	Value	Quantity	Value
Airfloat	1,180	67,100	1,210	68,600
Calcined 2/	1,570	248,000	1,510	260,000
Delaminated	1,230	140,000	1,280	158,000
Unprocessed	755 r/	13,200 r/	524	12,300
Water-washed	4,100 r/	488,000 r/	4,240	520,000
Total	8,830 r/	957,000 r/	8,770	1,020,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three sig may not add to totals shown.

2/ Includes both low-temperature filler and high-temperature refractory grades.

TABLE 15
CALCINED KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	High-temperature Quantity	High-temperature Value	Low-temperature Quantity	Low-temperature Value
1993				
Alabama and Georgia	1,250	215,000	W	W
Other 2/	238	5,680	83	27,800
Total	1,490	221,000	83	27,800
1994				
Alabama and Georgia	1,160	221,000	W	W
Other 2/	203	15,000	141	23,600
Total	1,370	236,000	141	23,600

W Withheld to avoid disclosing company proprietary data; included in "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes Arkansas, California, Pennsylvania, South Carolina, and items indicated by symbol W.

TABLE 16
GEORGIA KAOLIN SOLD OR USED BY PRODUCERS, BY KIND 1/

(Thousand metric tons and thousand dollars)

Kind	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Airfloat	720	35,400	758	37,100
Calcined 2/	1,090	234,000	1,110	241,000
Delaminated	1,230	140,000	1,280	158,000
Unprocessed	249	7,840	216	7,730
Water-washed	4,060 r/	486,000 r/	4,200	519,000
Total	7,340 r/	903,000 r/	7,570	962,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes both low-temperature filler and high-temperature refractory grades.

TABLE 17
GEORGIA KAOLIN 1/ 2/ SOLD OR USED BY PRODUCERS, BY USE

(Metric tons)

Use	1993	1994
Domestic:		
Ceramics and glass:		
Catalysts (oil-refining)	152,000 r/	154,000
Electrical porcelain	10,600	11,000
Fiber glass	256,000	271,000
Roofing granules	11,800	22,600
Sanitaryware	46,500	48,500
Other 3/	80,300	85,300
Fillers, extenders, and binder:		
Adhesives	56,600	42,400
Paint	211,000	228,000
Paper coating	2,510,000	2,630,000
Paper filling	872,000 r/	910,000
Plastic	28,200	26,900
Rubber	78,000	60,900
Other 4/	47,000 r/	42,200
Heavy clay products 5/	58,000 r/	47,900
Refractories 6/	570,000	570,000
Undistributed 7/	203,000	205,000
Total	5,190,000 r/	5,350,000
Exports:		
Paint	75,000	74,900
Paper coating	1,680,000	1,730,000
Paper filling	262,000 r/	259,000
Rubber	4,500	7,280
Undistributed 8/	127,000	150,000
Total	2,150,000 r/	2,220,000
Grand total	7,340,000 r/	7,570,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes high-temperature calcined, low-temperature calcined, and delaminated.

3/ Includes crockery/earthenware, fine china/dinnerware, glazes, glass, and enamels, pottery, and miscellaneous ceramics.

4/ Includes asphalt emulsion, asphalt tile, fertilizers, gypsum products, medical, pharmaceutical and cosmetics, pesticides and related products, textiles and miscellaneous fillers, extenders and binders, and ink.

5/ Includes brick (common and face), portland cement, and miscellaneous clay products.

6/ Includes firebrick, blocks and shapes, grogs and calcines, high-alumina specialties, kiln furniture, and miscellaneous refractories.

7/ Includes chemical manufacturing, civil engineering and sealings, drilling mud, filtering, clarifying, and decolorizing, floor and wall tiles, and other uses unknown.

8/ Includes fiber glass, sanitaryware, ink, miscellaneous fillers, extenders and binders, and other uses unknown.

TABLE 18
SOUTH CAROLINA KAOLIN SOLD OR USED BY PRODUCERS, BY KIND 1/

(Thousand metric tons and thousand dollars)

Kind	1993		1994	
	Quantity	Value	Quantity	Value
Airfloat	391	25,900	388	25,700
Unprocessed	143	902	W	W
Total	534	26,800	388	25,700

W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 19
SOUTH CAROLINA KAOLIN SOLD OR USED BY PRODUCERS, BY KIND AND USE 1/

(Metric tons)

Kind and use	1993	1994
Airfloat:		
Adhesives	W	W
Animal feed and pet waste absorbent	W	W
Ceramics 2/	3,440	13,400
Fertilizers, pesticides and related products	6,820	6,780
Fiber glass	W	W
Paint	W	W
Paper coating and filling	W	W
Plastics	W	W
Rubber	165,000	168,000
Refractories 3/	W	W
Other uses 4/	185,000	16,400
Exports 5/	30,600	31,300
Total	391,000	388,000
Unprocessed: Face brick and other uses	143,000	(6/)
Grand total	534,000	388,000

W Withheld to avoid disclosing company proprietary data; included with "Other uses."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2 Includes crockery and earthenware, fine china/dinnerware, floor and wall tile, pottery, and roofing granules.

3/ Includes refractory calcines and grogs, firebrick, blocks and shapes, refractory mortar and cement, and high-alumina refractories.

4/ Includes catalysts (oil refining), asphalt emulsion, gypsum products, and unknown uses.

5/ Includes paint, paper filling, and rubber.

6/ Withheld to avoid disclosing company proprietary data.

TABLE 20
KAOLIN 1/ SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE

(Metric tons)

Use	1993	1994
Domestic:		
Ceramics:		
Catalyst (oil and gas refining)	221,000 r/	213,000
Electrical porcelain	16,800	17,000
Fine china and dinnerware	10,400	20,700
Floor and wall tile	11,800	11,900
Pottery	24,100	22,500
Roofing granules	12,200	34,000
Sanitaryware	48,300	50,200
Miscellaneous	158,000	131,000
Chemical manufacture	146,000	167,000
Civil engineering	20,500	22,100
Glass fiber, mineral wool	347,000	364,000
Filler, extender, and binder:		
Adhesive	69,200	55,800
Fertilizer	W	W
Medical, pharmaceutical cosmetic	1	14
Paint	242,000	253,000
Paper coating	2,510,000	2,630,000
Paper filling	878,000 r/	917,000
Pesticide	15,800	12,900
Plastic	28,200	32,000
Rubber	243,000	240,000
Miscellaneous	56,500 r/	56,200
Heavy clay products:		
Brick, common and face	223,000	204,000
Miscellaneous	6,530	W
Portland cement	207,000	82,900
Refractories:		
Firebrick, block and shapes	21,400 r/	19,600
Grogs	938,000	260,000
High alumina brick, specialties, and kiln furniture	34,500	530,000
Foundry sand, mortar, cement, and miscellaneous refractories	67,500	63,000
Miscellaneous applications	72,100	95,900
Total	6,630,000 r/	6,500,000
Exports:		
Ceramics	63,900	79,500
Foundry sand, grogs and calcines; other refractories	W	W
Paint	75,100	75,100
Paper coating	1,680,000	1,730,000
Paper filling	262,000 r/	259,000
Rubber	35,100	38,600
Miscellaneous	82,200	89,200
Total	2,200,000 r/	2,270,000
Grand total	8,830,000 r/	8,770,000

r/ Revised. W Withheld to avoid disclosing proprietary data; included with "Miscellaneous applications" or "Miscellaneous."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 21
COMMON CLAY AND SHALE USED IN LIGHTWEIGHT AGGREGATE PRODUCTION IN THE UNITED STATES BY STATE 1/

(Thousand metric tons and thousand dollars)

State	Concrete block	Structural oncrete	Highway surfacing	Other	Total	Total value e/
1993						
Alabama and Arkansas	751	77	17	1	846	11,300
California	76	102	--	45	223	755
Florida and Indiana	125	34	--	--	159	1,500
Kansas, Kentucky, and Louisiana	295	128	--	70	493	1,120
Mississippi and Missouri	15	1	2	90	109	1,220
New York and Montana	192	182	--	--	374	8,480
North Carolina	301	52	--	8	360	4,050
Ohio, Oklahoma, and Pennsylvania	162	31	--	--	193	1,350
Texas	49	157	222	31	459	2,520
Utah and Virginia	251	22	2	42	316	3,830
Total	2,220	787	243	286	3,530	36,100
1994						
Alabama and Arkansas	857	101	20	75	1,050	14,500
California	76	102	--	45	223	755
Florida and Indiana	125	34	--	--	159	1,500
Kansas, Kentucky, and Louisiana	361	128	--	17	505	1,150
Mississippi and Missouri	15	1	2	127	145	1,700
New York and Montana	192	182	--	--	374	8,480
North Carolina	301	52	--	9	361	4,050
Ohio, Oklahoma, and Pennsylvania	162	31	--	(2/)	193	1,350
Texas	49	157	222	32	460	2,550
Utah and Virginia	264	13	2	--	279	3,010
Total	2,400	801	247	305	3,750	39,100

e/ Estimated.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

TABLE 22
COMMON CLAY AND SHALE USED IN BUILDING BRICK PRODUCTION IN THE UNITED STATES, BY STATE 1/ 2/

(Thousand metric tons and thousand dollars)

State	1993		1994	
	Quantity	Value e/	Quantity	Value e/
Alabama	798	2,720	715	2,960
Arkansas	423	888	459	919
California	313	1,720 r/	300	1,420
Colorado	260	2,060	272	2,110
Connecticut, New Jersey 3/, and New York 3/	329	3,010	300	2,780
Georgia	1,200	9,000	1,260	8,890
Illinois	437	546	454	633
Indiana and Iowa	263	1,480	296	1,580
Kentucky 3/ and Tennessee 3/	790	1,920	814	2,130
Maine, Massachusetts 3/, and New Hampshire 3/	W	W	W	W
Maryland and West Virginia 4/	289	612	271	792
Mississippi and Missouri	486	1,760 r/	496	1,870
North Carolina	1,930	6,030	2,080	7,370
Ohio	911	4,370 r/	863	4,140
Oklahoma	290	1,460	427	2,130
Pennsylvania	637	2,460	626	2,100
South Carolina	599	3,410	731	3,450
Texas	1,040	7,440 r/	1,050	4,800
Virginia	562	1,770	658	2,070
Other 5/	779	3,520	883	3,440
Total	12,300	56,200 r/	13,000	55,600

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Includes extruded and other brick.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Extruded brick only.

4/ Includes other brick only.

5/ Includes Arizona, Minnesota, New Mexico, North Dakota, and Wyoming.

TABLE 23
U.S. EXPORTS OF CLAYS IN 1994, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	Ball clay		Bentonite		Fire clay		Fuller's earth	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	(2/)	67	(2/)	14	(2/)	9
Australia	1	26	25	1,040	21	1,830	--	--
Belgium	--	--	9	3,320	--	--	(2/)	26
Brazil	(2/)	20	(2/)	199	(2/)	13	--	--
Canada	--	--	206	15,200	7	1,220	9	1,110
Finland	(2/)	13	(2/)	152	--	--	--	--
France	--	--	40	2,820	1	142	(2/)	36
Germany	1	34	4	1,040	1	172	(2/)	18
Indonesia	--	--	8	558	1	166	(2/)	29
Italy	--	--	2	1,010	(2/)	13	3	723
Japan	29	836	275	18,300	46	4,750	1	61
Korea, Republic of	(2/)	16	16	2,500	5	1,470	(2/)	10
Malaysia	--	--	24	1,400	(2/)	7	14	2,280
Mexico	43	1,790	9	978	52	4,330	9	684
Netherlands	(2/)	20	1	536	75	7,920	21	2,020
Singapore	(2/)	4	10	1,180	--	--	1	229
South Africa, Republic of	(2/)	12	1	244	(2/)	43	2	402
Sweden	--	--	(2/)	175	(2/)	14	(2/)	9
Taiwan	(2/)	20	35	4,240	6	814	--	--
Thailand	--	--	10	1,140	(2/)	63	(2/)	10
United Kingdom	(2/)	3	8	2,400	1	98	6	561
Venezuela	(2/)	45	25	1,410	1	478	(2/)	111
Other	7	637	60	2,490	8	792	8	1,510
Total	81	3,470	768	69,500	225	24,300	74	9,820

Country	Kaolin		Clays, n.e.c. 3/		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	13	2,120	1	485	14	2,700
Australia	31	10,600	1	2,190	78	15,700
Belgium	35	9,440	1	2,320	46	15,100
Brazil	2	1,170	1	3,310	4	4,720
Canada	606	74,800	165	28,600	994	121,000
Finland	457	67,600	1	251	458	68,000
France	6	1,350	3	1,270	50	5,620
Germany	60	12,600	4	3,180	71	17,000
Indonesia	44	8,790	1	987	54	10,500
Italy	165	24,300	1	568	171	26,600
Japan	777	145,000	5	6,300	1,130	175,000
Korea, Republic of	139	29,500	4	4,040	165	37,500
Malaysia	2	640	3	889	43	5,210
Mexico	184	23,400	9	2,060	305	33,200
Netherlands	146	22,200	13	4,820	256	37,500
Singapore	3	872	7	2,740	21	5,020
South Africa, Republic of	21	4,010	2	1,200	26	5,910
Sweden	115	23,900	15	2,510	131	26,600
Taiwan	121	20,200	5	2,170	167	27,500
Thailand	21	6,310	(2/)	763	32	8,290
United Kingdom	110	13,400	15	12,400	140	28,800
Venezuela	22	3,410	7	2,630	56	8,080
Other	95	26,500	31	14,300	205	53,300
Total	3,180	532,000	295	100,000	4,620	739,000

1/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Also includes chamotte or dinas earth, activated clays and earths, and artificially activated clays.

Source: Bureau of the Census.

TABLE 24
U.S. IMPORTS FOR CONSUMPTION OF CLAY IN 1994, BY KIND 1/

Kind	Quantity (metric tons)	Value (thousands)
China clay or kaolin:		
Canada	1	$2
China	5,120	620
New Zealand	1,250	730
United Kingdom	3,970	2,390
Other	453	289
Total	10,800	4,030
Fire clay:		
Canada	187	35
Netherlands	263	122
Philippines	2	7
United Kingdom	539	288
Other	36	12
Total	1,030	464
Decolorizing earths and fuller's earth:		
Canada	47	10
France	22	9
Germany	56	15
Japan	1,320	31
Total	1,440	65
Bentonite:		
Canada	647	232
Japan	230	39
Mexico	390	81
United Kingdom	580	324
Other	205	106
Total	2,050	782
Common blue clay and other ball clay:		
Netherlands	40	7
United Kingdom	796	274
Total	836	281
Other clay:		
Canada	212	331
Germany	54	66
Italy	3	7
South Africa, Republic of	180	177
United Kingdom	1,020	396
Other	161	237
Total	1,630	1,210
Chamotte or dina's earth:		
China	4,870	267
Taiwan	2	2
Total	4,870	269
Artificially activated clay and activated earth:		
Canada	562	322
Germany	1,820	3,640
Mexico	10,000	2,930
Other	439	885
Total	12,900	7,780
Grand total	35,500	14,900

1/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 25
BENTONITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Algeria 4/	33,700	25,800	31,000 r/	30,000 e/	30,000
Argentina	107,000 r/	108,000 r/	97,500 r/	96,700 r/	97,000
Australia e/ 4/	35,000	35,000	35,000	35,000	35,000
Bosnia and Herzegovina e/	XX	XX	1,000	800	1,000
Brazil (beneficiated)	180,000	130,000	131,000 r/	113,000 r/	130,000
Burma	416	684 r/	693 r/	200 r/	300
Chile	1,210	1,050	1,080 r/	989 r/	1,000
Croatia e/	XX	XX	10,000	10,000	10,000
Cyprus	82,000	58,500	58,800	60,000 e/	50,000
Egypt e/	4,900 5/	4,900	4,900	4,900	4,900
France e/	10,000	10,000	6,000 5/	6,000 r/	7,000
Germany: Western states	577,000	583,000	581,000	473,000 r/	475,000
Greece	593,000	600,000	600,000 e/	600,000 e/	500,000
Guatemala e/	9,000	12,000	12,600	12,300	4,410 5/
Hungary	36,600	18,100	23,000	25,000 e/	25,000
Indonesia	5,910	21,500	18,000	13,700 r/	14,000
Iran 6/	51,100	40,500	47,700	85,000 r/	84,000 5/
Italy	228,000	385,000	150,000 r/	-- r/	--
Japan	549,000	554,000	534,000	517,000 r/	484,000 5/
Macedonia e/	XX	XX	40,000	35,000	30,000
Mexico	145,000	145,000	136,000	94,600 r/	100,000
Morocco	4,000 e/	9,230	8,140	10,200 r/	10,200
Mozambique	--	664	20	100 e/	3,350 5/
New Zealand (processed)	1,390	--	--	1,610 r/	1,500
Pakistan	3,240	5,110	6,060	7,990 r/	8,000
Peru	45,000 e/	55,300	14,500	14,500	14,500
Philippines	14,600 r/	42,100	31,900	5,050 r/	25,000
Poland	69,000	38,000	40,000 e/	40,000 e/	40,000
Romania e/	150,000	150,000	120,000	120,000	110,000
Serbia and Montenegro e/	XX	XX	5,000	5,000	5,000
South Africa, Republic of 7/	66,100	64,600	44,000	50,400 r/	71,800 5/
Spain e/	151,000 5/	150,000	150,000	150,000	150,000
Tanzania e/	75	75	70	70	70
Turkey	97,500	124,000	124,000	382,000 r/	300,000
U.S.S.R. e/ 8/	2,700,000	2,400,000	2,000,000	1,600,000	1,300,000
United States	3,470,000	3,430,000	2,950,000	2,870,000 r/	3,290,000 5/
Yugoslavia 9/	103,000	85,000 e/	XX	XX	XX
Zimbabwe 7/	99,900	99,900	83,000	83,000 e/	169,000 5/
Total	9,620,000 r/	9,390,000 r/	810,000 r/	7,550,000 r/	7,580,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 12, 1995.

3/ In addition to the countries listed, Canada and China are believed to produce bentonite, but output is not reported, and available information is inadequate to make reliable estimates of ouput levels.

4/ Includes bentonitic clays.

5/ Reported figure.

6/ Year beginning Mar. 21 of that stated.

7/ May include other clays.

8/ Dissolved in Dec. 1991; however, information if inadequate to formulate reliable estimates for individual countries.

9/ Dissolved in Apr. 1992.

TABLE 26
FULLER'S EARTH: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Algeria	7,840 r/	4,530	3,660 r/	3,230 r/	3,250
Argentina e/	2,000	2,000	1,500	1,600	1,600
Australia (attapulgite) e/	20,000	15,000	15,000	15,000	15,000
Germany: Western states (unprocessed)	653,000	708,000	673,000	670,000 e/	650,000
Italy	45,800	23,400 r/	30,000 r/	30,000 e/	30,000
Mexico	29,900	41,100	41,100	36,100 r/	36,100 4/
Morocco (smectite)	45,200	37,600	38,100 r/	38,700 r/	22,800 4/
Pakistan	16,500	22,100	22,000	20,900 r/	21,000
Senegal (attapulgite)	115,000	129,000	112,000	112,000 e/	112,000
South Africa, Republic of (attapulgite)	7,630	8,110	8,240	7,030 r/	10,100 4/
Spain (attapulgite) e/	53,900 r/	72,900 r/	87,300 r/	85,000 r/	85,000
United Kingdom 5/	205,000 r/	189,000	189,000 r/	187,000 r/	190,000
United States 6/	2,310,000	2,740,000	2,410,000	2,450,000	2,640,000 4/
Total	3,510,000 r/	3,990,000 r/	3,640,000 r/	3,660,000 r/	3,820,000

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits may not add to totals shown.

2/ Excludes centrally planned economy countries and former such countries, some of which presumably produce fuller's earth, but for which no information is available. Table includes data available through July 12, 1995.

3/ In addition to the market economy countries listed, France, India, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

4/ Reported figure.

5/ Salable product.

6/ Sold or used by producers.

TABLE 27
KAOLIN: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Algeria	18,000	21,500	21,500	21,500	21,500
Argentina	33,900 r/	47,100 r/	43,700 r/	42,100 r/	43,000
Australia (includes ball clay) e/	200,000	190,000	180,000	180,000	200,000
Austria (marketable)	81,300	72,400 r/	64,700 r/	64,400 r/	87,000
Bangladesh 4/	7,220	7,340	7,300 e/	7,500	7,500
Belgium e/	175,000	260,000 5/	325,000	300,000	300,000
Bosnia and Herzegovina e/	XX	XX	3,000	3,000	3,000
Brazil (beneficiated)	659,000	746,000	790,000 r/	750,000	760,000
Bulgaria	186,000	106,000	104,000 r/	110,000 e/	110,000
Burundi	5,280	6,680	9,690	5,000 e/	5,000
Chile	32,400	63,100	59,100 r/	66,900 r/	67,000
Colombia (includes common clay) e/	1,920,000 r/	1,980,000 r/	2,050,000 r/	2,100,000 r/	6,700,000 5/
Czech Republic	XX	XX	XX	2,340,000 r/	2,710,000 5/
Czechoslovakia (marketable) 6/	872,000	705,000	700,000 e/	XX	XX
Denmark (sales)	17,400	17,100	3,500	3,500 e/	3,500
Ecuador	7,880	4,050 r/	3,920 r/	1,940 r/	2,000
Egypt	49,000	193,000	190,000 e/	157,000 r/	157,000
Ethiopia e/ 7/	670	370	420	500	400
France (marketable)	370,000 r/	344,000 r/	334,000	295,000 r/ e/	300,000
Germany:					
Eastern states (marketable) e/	200,000	XX	XX	XX	XX
Western states (marketable)	684,000	XX	XX	XX	XX
Total e/	884,000	684,000	1,190,000 r/	981,000 r/	1,000,000
Greece	170,000	189,000	200,000 r/ e/	200,000 r/ e/	200,000
Guatemala	2,050	3,280	2,860	3,000 e/	3,000
Hungary (processed)	28,600	14,100	7,000 r/	15,000 r/	15,000 5/
India:					
Saleable crude	631,000	628,000	625,000 e/	519,000 r/	550,000
Processed	104,000	113,000	110,000 e/	129,000 r/	150,000
Indonesia	160,000	140,000	231,000	42,400 r/	45,000
Iran	150,000 e/	150,000	264,000	452,000 r/	450,000
Israel e/	42,200 5/	53,000	53,000	53,000	53,000
Italy:					
Crude	67,300	57,900 r/	33,000 r/	-- r/	--
Kaolinitic earth	17,900	16,000	15,000 e/	10,000 r/ e/	10,000
Japan	165,000 r/	130,000	123,000	110,000	114,000 5/
Korea, Republic of	1,450,000	1,760,000	1,860,000	2,330,000 r/	2,600,000
Madagascar	485	496	756	700 e/	700
Malaysia	153,000	187,000	245,000	250,000	253,000 5/
Mexico	156,000	167,000	144,000	216,000 r/	216,000 5/
New Zealand	25,400	21,300	27,500 r/	26,500 r/	28,000
Nigeria e/	1,360 5/	1,300	1,300	1,300	1,300
Pakistan	61,600	44,700	37,400	37,200 r/	38,000
Paraguay e/	74,000	74,000	74,000	74,000	74,000
Peru e/	8,000	7,100	5,500	5,500	5,500
Poland	48,100 r/	44,100 r/	42,400 r/	44,000 r/ e/	44,000
Portugal	108,000 r/	150,000 r/	100,000 r/ e/	75,000 r/ e/	75,000
Romania e/	250,000	250,000	200,000	200,000	200,000
Serbia and Montenegro:					
Crude	XX	XX	112,000 r/	36,600 r/	50,000
Washed	XX	XX	9,300 r/	4,800 r/	5,000
Slovakia	XX	XX	--	25,000	25,000
Slovenia: e/					
Crude	XX	XX	15,000	10,000	10,000
Washed	XX	XX	5,000	4,000	4,000
South Africa, Republic of	132,000	134,000	132,000	147,000 r/	131,000 5/
Spain (marketable): 8/					
Crude e/	125,000	125,000	74,500 r/ 5/	75,000 r/	75,000
Washed	423,000	413,000 e/	305,000 r/	150,000 r/ e/	75,000
Sri Lanka	7,730	7,740	6,760	7,000 e/	7,500
Sweden e/	108 5/	100	100	100	100
Taiwan	105,000	93,000	100,000 e/	100,000 e/	100,000
Tanzania	2,020	1,740	1,700 e/	1,700 e/	1,700
Thailand (beneficiated)	208,000	256,000	301,000	397,000 r/	415,000

See footnotes at end of table.

TABLE 27--Continued
KAOLIN: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Turkey	251,000	187,000	134,000	139,000 r/	150,000
U.S.S.R. e/ 9/	1,800,000	1,600,000	1,300,000	1,000,000	800,000
United Kingdom (sales)	3,040,000	2,910,000	2,500,000 r/ 10/	2,580,000 r/ 10/	2,600,000
United States 11/	9,760,000	9,570,000	8,740,000	8,830,000 r/	8,320,000
Venezuela	12,000	39,000	37,000	22,000 r/	25,000
Vietnam e/	750	800	800	800	1,000
Yugoslavia 12/	199,000	170,000 e/	XX	XX	XX
Zimbabwe	--	65	83	90 e/	462
Total	25,500,000 r/	25,200,000 r/	24,200,000 r/	25,700,000 r/	30,400,000

e/ Estimated. r/ Revised. XX Not Applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digts; may not add to totals shown.

2/ Table includes data available through July 12, 1995.

3/ In addition to the countries listed, China, Lebanon, Morocco, and Suriname may also have produced kaolin, but information is inadequate to make reliable estimates of output levels.

4/ Data for year ending June 30 of that stated.

5/ Reported figure.

6/ Dissolved in Dec. 1992.

7/ Data for year ending July 7 of that stated.

8/ Includes crude and washed kaolin and refractory clays not further described.

9/ Dissolved in Dec. 1991. This commodity is believed to be produced mainly in Uzbekistan and Ukraine; however, information is inadequate to formulate reliable estimates of individual country production.

10/ Dry weight.

11/ Kaolin sold or used by producers.

12/ Dissolved in Apr. 1992.

COBALT

By Kim B. Shedd

Cobalt is a strategic and critical metal used in many diverse industrial and military applications. The largest use of cobalt is in superalloys, which are alloys designed to resist stress and corrosion at high temperatures. Superalloys are used in turbine engine parts for aircraft jet engines and land-based industrial gas turbines. Cobalt is also used to make magnets for a wide range of motors, meters, and devices; corrosion and wear-resistant alloys for hardfacing and castings; and high speed steels for cutting tools. Cobalt metal powder acts as a binder in cemented carbides and diamond tools, which are used for metal cutting and forming, mining, and oil and gas drilling. Cobalt compounds are used in catalysts for the petroleum and chemical industries; drying agents for paints, varnishes, and inks; ground coats for porcelain enamels; pigments for ceramics, paints, and plastics; battery electrodes; steel-belted radial tires; and magnetic recording media.

The United States is the world's largest consumer of cobalt, but has no domestic production, so it relies on imports to meet its primary cobalt needs. The United States stocks significant quantities of cobalt metal in the National Defense Stockpile (NDS) for military, industrial, and essential civilian use during a national emergency.

World cobalt supply and demand were estimated to be in a close balance during 1994. World production increased, reversing a trend of decreasing production that began in 1991. Cobalt sales from the NDS and exports from Russia continued to contribute to supply. World cobalt demand increased as the western world's economies improved, although increased use of secondary and intermediate materials lessened the demand for primary metal. Cobalt prices increased rapidly in January, then fluctuated within the $20 to $30 per pound range for the remainder of the year.

With the exception of prices, all data in this report have been rounded to three significant digits. Totals and percentages were calculated from unrounded numbers.

Legislation and Government Programs

The Defense Logistics Agency (DLA) continued its bimonthly sales of cobalt from the NDS. The sales were intended to bring the NDS cobalt inventory down to 18,300 metric tons (40.4 million pounds) as set in the U.S. Department of Defense 1992 Report to the Congress on National Defense Stockpile Requirements. Approximately 181 tons (400,000 pounds) of cobalt granules was available on the second Wednesday of each month and 68 tons (150,000 pounds) of cobalt rondelles was available on the fourth Wednesday of each month. The DLA made awards at prices close to those quoted by Metal Bulletin for 99.3% cobalt.

The DLA sold 1,800 tons of cobalt during fiscal year 1994 (October 1, 1993 through September 30, 1994). Sixty-eight percent of the cobalt sold was granules and 32% was rondelles. The sales represented 86% of the quantity allowable for sale under the Annual Materials Plan (AMP) for fiscal year 1994—2,090 tons (4.6 million pounds). According to DLA's AMP for fiscal year 1995, the maximum amount of cobalt that could be sold in the year beginning October 1, 1994, would be 1,720 tons (3.8 million pounds). The quality of the granules and rondelles available for sale in fiscal year 1995 was reduced to a maximum cobalt content of 99.22%.

The DLA sold 1,720 tons of cobalt during calendar year 1994. Sixty-four percent of the cobalt sold was granules and 36% was rondelles. At yearend, the total uncommitted cobalt inventory held by the DLA was approximately 21,900 tons and the quantity authorized for eventual disposal was 3,760 tons.

Production

There was no domestic mine or refinery production of cobalt in 1994. U.S. processors made cobalt chemicals and cobalt metal powders from cobalt metal and/or cobalt-bearing scrap. U.S. Bureau of Mines (USBM) data on chemical and metal powder production were developed from a voluntary survey of U.S. cobalt processors. Seven of the eight companies canvassed on this survey responded. Estimates were made for the nonresponding company. U.S. processors produced 1,850 tons of cobalt oxide and hydroxide, inorganic cobalt compounds, and organic cobalt compounds in 1994, 6% less than the 1,980 tons produced in 1993. Because this figure includes production of intermediate forms, it does not represent net production. Shipments are defined as sales, transfers, or consumption to make end-use products such as paint driers and catalysts. In 1994, shipments by U.S. processors included 1,730 tons of cobalt oxide and hydroxide, inorganic cobalt compounds, and organic cobalt compounds, a slight decrease from 1993 shipments of 1,790 tons. Two processors made extra-fine cobalt metal powder in the United States. Carolmet, owned by Union Minière S.A. of Belgium, made cobalt metal powder from imported primary metal at its Laurinburg, NC, plant. Osram Sylvania Inc. made cobalt metal powder from recycled materials in Towanda, PA. Production and shipments of cobalt metal powder are withheld to avoid disclosing company proprietary data.

U.S. cobalt supply included secondary cobalt from alloy scrap, cemented carbide scrap, and spent catalysts. Cobalt intermediate products were recovered from spent petroleum catalysts by AMAX Metals Recovery, Inc. in Braithwaite, LA; Dakota Catalyst Products of Williston, ND; and Gulf Chemical and Metallurgical Corp. in Freeport, TX.

Consumption

Domestic data on cobalt consumption were developed by the USBM from three separate, voluntary surveys of U.S. operations. Most of the data on cobalt chemical uses were obtained from the cobalt processors survey. The second survey covered a broad range of metal-consuming companies, such as superalloy producers, magnetic alloy producers, and tungsten carbide producers.

For this survey, more than 100 cobalt consumers were canvassed on a monthly or annual basis. The USBM also canvassed 13 superalloy scrap recyclers to determine the consumption of secondary cobalt in superalloy production. The data in tables 1 and 2 contain estimates to account for nonrespondents.

U.S. reported consumption was 7% higher than reported consumption for 1993. As a whole, metallurgical industries consumed 11% more cobalt in 1994 than in 1993. On an industry-by-industry basis, superalloy melters, cemented carbide producers, producers of welding materials, magnetic alloy producers, and producers of other alloys consumed more cobalt in 1994 than they did in 1993, while steel producers and producers of mill products from metal powder consumed less cobalt in 1994 than in 1993. Total cobalt consumption for chemical uses was essentially the same in 1994 and 1993. Consumption in pigments, decolorizers, and driers increased, while consumption in catalysts, ground coat frits, and feed materials decreased. *(See table 2.)*

Apparent consumption, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, increased 15% in 1994 to approximately 8,400 tons. A 14% increase in cobalt imports and significant sales of cobalt from the NDS contributed to the large increase in apparent consumption. However, if some of this cobalt went into stocks that were not reported to the USBM, the calculated apparent consumption would be higher than actual consumption. If this is the case, a corresponding seemingly low apparent consumption will result in the next few years when these stocks are consumed.

Stocks

As indicated above, cobalt stocks remain an important component of supply, but information on actual quantities is not readily available from all sources. Wide ranges in estimates of stock levels can result when a distinction is not made between stocks of refined cobalt and intermediate materials. Movement of stocks between producers, processors, consumers, governments, and traders can make it difficult to quantify actual consumption. The total amount of cobalt contained in stocks held by U.S. cobalt processors and consumers was 13% higher at yearend 1994 than at yearend 1993. *(See table 2.)*

Prices

Market prices for cobalt were high throughout the year. *(See figure 1.)* The U.S. spot cathode price reported by Platt's Metals Week was lowest during the first week in January when it was approximately $18 per pound and highest in late December, when it was approximately $30 per pound. Platt's 1994 average annual U.S. spot cathode price was $24.66 per pound.

Metal Bulletin reported market prices for two grades of cobalt—minimum 99.3% cobalt and higher quality minimum 99.8% cobalt. Prices for the two grades of cobalt more or less paralleled one another. In early January, 99.3% cobalt was quoted at about $2 per pound less than 99.8% cobalt. From mid-January until mid-August, price quotes for 99.3% cobalt were between $3.50 and $5.50 per pound lower than quotes for 99.8% cobalt. The price differential narrowed to $1 per pound in early December, then widened by yearend to about $2.50 per pound.

In late January, La Générale des Carrières et des Mines (Gécamines) of Zaire and Zambia Consolidated Copper Mines Ltd. (ZCCM) met to review the cobalt market and decide on 1994 cobalt pricing. Gécamines and ZCCM agreed to maintain the price at $18 per pound, but decided to change from a fixed annual producer price to a more flexible 3-month reference price. The change from a producer price to a reference price gave the producers the flexibility of taking free market prices into account when establishing their sales prices. On May 20, the reference price was increased to $21 per pound, applicable to Zambian grade B cobalt (quality 3 and 4) and Zairian granules. On October 13, the reference price was increased to $25 per pound.

Foreign Trade[1]

U.S. imports of unwrought cobalt and cobalt in chemicals increased 14% in 1994. More than 90% of these imports were supplied by seven countries. Zambia was the leading supplier of cobalt to the United States, followed by Norway, Finland, Russia, Canada, Zaire, and Belgium. Cobalt imports from Belgium, Finland, and Russia increased significantly in 1994 as compared with imports in 1993. *(See figure 2 and tables 3 and 4.)*

In 1994, the United States imported 103 tons, gross weight, of unwrought cobalt alloys valued at $3.5 million. Six countries supplied 87% of these materials: Sweden (20%), the Republic of South Africa (17%), Japan and the United Kingdom (15% each), Canada (11%), and Germany (9%). The United States imported 756 tons, gross weight, of cobalt matte, waste, and scrap, valued at $8.9 million. Six countries supplied more than 90% of these materials: the United Kingdom (27%), Russia (22%), the Republic of South Africa (18%), France (13%), Germany (7%), and Belgium (5%). The United States also imported 185 tons, gross weight, of wrought cobalt and cobalt articles valued at $8.4 million. The leading suppliers of these materials were the United Kingdom (49%), Japan (19%), and Germany (18%), followed by Canada (7%), and France (6%).

U.S. exports of unwrought cobalt and cobalt contained in chemicals increased 71% as compared with exports in 1993, bringing them back to the levels exported during 1990 through 1992. Nearly 60% of 1994 cobalt metal and chemical exports was shipped to four countries: Canada, France, Japan, and Mexico. The remainder was shipped to 37 other countries. *(See table 5.)*

Exports also included 665 tons, gross weight, of wrought metal and cobalt articles valued at $24.5 million. More than 90% of these materials was sent to seven countries: Belgium (45%), France (13%), Norway (10%), Japan (9%), Canada (8%), and the United Kingdom and India (each 4%). The remainder was shipped to 22 other countries. In addition, the United States exported 71 tons, gross weight, of material under the category entitled, "Cobalt ores and concentrates." The material, valued at $558,000 was sent to Canada.

World Review

World cobalt production increased in 1994, reversing the trend of decreasing production that began in 1991. Refinery production reported by the seven Cobalt Development Institute (CDI) member producers increased 7% from 13,800 tons in 1993 to 14,900 tons in 1994.[2] Falconbridge Ltd., OM Group, Inc., and Sherritt Inc. reported record-high production levels in

1994. Production by Gécamines also increased in 1994, while production by Inco Ltd., Sumitomo Metal Mining Co. Ltd., and ZCCM decreased. The CDI estimated Western World cobalt supply, including production by CDI-member producers, production by non-CDI producers (with the exception of Russian production), secondary production by CDI processors, Russian exports, and DLA sales, to be 22,900 tons. The CDI estimated 1994 demand to be between 21,500 and 22,000 tons, balancing supply.

Australia.—In the 12-month period ending June 30, 1994, QNI Ltd. produced 1,390 tons of cobalt in cobalt sulfide at the Yabulu nickel-cobalt refinery in Townsville, Queensland. More than 90% of the laterite feed for the refinery was imported from Indonesia and New Caledonia. The remainder was from the company's Brolga Mine in Queensland. QNI's cobalt sulfide was sold to OM Group for refining at its Kokkola Chemicals Oy refinery in Finland. During the year, QNI expanded its research and development program. In addition to continuing a study on the potential for upgrading its cobalt sulfide to value-added products, QNI planned to improve its cobalt recovery rates and to investigate processing methods for new ores and concentrates.[3]

Western Mining Corp. (WMC) produced intermediate cobalt products as a byproduct of mining, smelting, and refining nickel sulfide ores in Western Australia. Some of the nickel-copper-cobalt matte produced at WMC's Kalgoorlie smelter was exported to other refiners, including Sumitomo Metal Mining Co. of Japan. The remainder was refined by WMC at its Kwinana nickel refinery. The Kwinana refinery produced cobalt in a nickel-cobalt mixed sulfide, which has traditionally been refined by Sherritt Inc. in Canada.

Late in the year, WMC commissioned its Mount Keith nickel sulfide mine in Western Australia. WMC planned to produce about 140,000 tons of concentrates per year, grading about 20% nickel and 0.5% cobalt.[4] One-half of the concentrates were to be smelted at Kalgoorlie and one-half were to be sold to Outokumpu Oy for treatment at its Harjavalta refinery in Finland.

WMC decided to withdraw from the Bulong project, leaving Resolute Resources Ltd. with 100% ownership. Resolute planned to continue the feasibility study on the nickel-cobalt laterite deposit, located east of Kalgoorlie in Western Australia. Estimates of potential cobalt production from the Bulong deposit ranged from 1,270 tons to 2,400 tons per year.[5] [6] Samantha Gold NL of Perth, Western Australia, acquired Resolute Resources late in the year.

Outokumpu Australia Pty. Ltd. produced about 250 tons of cobalt in nickel sulfide concentrates from its Forrestania Mine southwest of Kalgoorlie, in Western Australia.[7] The concentrate was exported to Finland for treatment at Outokumpu's Harjavalta refinery.

MIM Holdings Ltd. and Savage Resources Ltd. studied the feasibility of mining the Ernest Henry copper-gold deposit near Cloncurry, Queensland. Preliminary hydrometallurgical research indicated that about 3,000 tons of cobalt could be recovered annually from the flotation mill tailings.[8] In addition, MIM completed a feasibility study on the bacterial leaching of cobalt from its Mount Isa copper concentrates. Potential cobalt production from the Mount Isa Mine was estimated at 600 tons per year.[9]

Belgium.—Union Minière (UM) converted cobalt metal, residues, and other cobalt-bearing materials into cobalt metal powders, oxides, hydroxide, and chloride at its facilities in Olen, Belgium. Early in the year, UM began treating cobalt-bearing residues from the zinc refining industry. This cobalt is considered primary cobalt production. An estimate of Union Minière's refinery capacity is included in table 6. Cobalt products made from refined metal and secondary materials are not considered primary production and are excluded from the estimate. In September, UM concluded a contract to purchase cobalt-bearing raw materials from Russian nickel-cobalt producer Severonickel in Monchegorsk, on the Kola Peninsula.

Canada.—In 1994, Falconbridge produced 620 tons of cobalt from nickel-copper ores at its Sudbury, Ontario, operations, a decrease from the 770 tons produced in 1993. Falconbridge also produced 740 tons of cobalt from custom feed, as compared with 770 tons in 1993.[10] Cobalt-containing nickel-copper matte from the Sudbury smelter was refined at Falconbridge's Nikkelverk refinery in Norway.

Inco produced cobalt oxide at its Thompson, Manitoba, refinery and cobalt cathode at its Port Colborne, Ontario, refinery. Feed materials for the two refineries originated from nickel mines in Thompson, Manitoba, and Sudbury, Ontario, respectively. Inco produced 1,130 tons of cobalt in 1994, a 20% decrease from its 1993 production of 1,410 tons.[11] The decrease in production was the result of planned cutbacks in nickel production and accidents at Inco's Ontario and Thompson operations.

Sherritt refined nickel-cobalt materials from Cuba and elsewhere at its Fort Saskatchewan refinery in Alberta. In 1994, Sherritt completed the expansion and modernization of the refinery, bringing its cobalt capacity to 2,000 tons per year. A record 1,820 tons of cobalt was produced at Fort Saskatchewan, an increase of 49% over the 1,220 tons produced in 1993.[12] In December, Sherritt established a joint-venture enterprise with its Cuban feed materials supplier. The Fort Saskatchewan refinery became part of the joint-venture's assets *(see Cuba section of this report.)* Sherritt's Westaim research subsidiary, a partnership with the Governments of Alberta and Canada, developed a unique process to produce lithium cobalt dioxide powder for rechargeable lithium ion batteries. Sherritt planned to commission a pilot plant for the production of these powders in 1995.

Ego Resources Ltd. began construction of a cobalt recovery plant near the historic silver mining town of Cobalt, in eastern Ontario. The plant was designed to use a hydrometallurgical process developed by Ego Resources' wholly owned subsidiary, Cobatec Ltd. Ego planned to produce cobalt compounds from local silver-cobalt ores and tailings. The plant was to have an annual capacity of 300 tons contained cobalt.

China.—In 1994, China consumed an estimated 1,650 tons of cobalt and produced an estimated 1,200 tons of cobalt metal, oxide, and salts.[13] Cobalt was produced from both domestic and imported raw materials. At Jinchuan, Gansu Province, cobalt metal was produced as a byproduct of nickel from the refining of domestic nickel sulfide ores. Jinchuan's future cobalt production was expected to increase as a result of a two-fold expansion of the refinery's nickel capacity. The Ganzhou cobalt refinery in Jiangxi Province produced cobalt metal and salts from cobalt arsenide concentrates imported from Morocco. Minor production sites included the Zibo Cobalt Works in Shandong Province, where cobalt metal was produced from iron ore from Shandong Province and copper ore from Shanxi Province.

Cuba.—Cuban laterites were refined to nickel-cobalt sulfides at Moa Bay and nickel oxide and oxide sinter at Nicaro and Punta Gorda. Most of the nickel-cobalt sulfides from Moa Bay were sent to Sherritt in Fort Saskatchewan, Canada, to be further refined. In December, Sherritt finalized a joint-venture agreement with La Compania General de Niquel S.A. (General Nickel) to mine, refine, and market nickel and cobalt. The agreement established three corporations, each owned 50-50 by Sherritt and General Nickel. Moa Nickel S.A. was to be responsible for mining and processing operations at Moa Bay; The Cobalt Refinery Company Inc. was to be responsible for metal refining at Fort Saskatchewan; and The International Cobalt Company Inc. was to be responsible for sales and marketing. The Cuban government granted mining concessions to the joint venture sufficient to supply the Moa Bay plant for approximately 25 years and additional reserves that could extend production for a further 25 years. The joint venture planned to upgrade the Moa Bay facilities and expand annual production to the design capacity of approximately 24,000 tons of nickel-cobalt sulfide, containing about 2,200 tons cobalt, by the year 2000.[14]

In September, WMC agreed in principle to form a joint venture with state-owned Commercial Caribbean Nickel S.A. (CCN) to assess and, if viable, develop the Pinares de Mayari West laterite deposit in Holguín Province. Preliminary data provided by CCN suggested that the deposit contains more than 200 million tons of ore with an average grade of more than 1% nickel and 0.1% cobalt. WMC would earn a 65% share in the project by funding delineation drilling, metallurgical testing, and a feasibility study.[15]

Nickel and cobalt of Cuban origin cannot be imported into the United States because of a U.S. embargo on imports from Cuba.

Finland.—OM Group's Kokkola Chemicals Oy refinery produced a record 3,000 tons of cobalt in cobalt metal powders, oxides, and salts,[16] a 36% increase over the 2,200 tons produced in 1993. The refinery uses cobalt sulfide from QNI Ltd. in Queensland, Australia, cobalt slag from Gécamines in Zaire, and cobalt hydroxide sludge from Outokumpu's Harjavalta, Finland, refinery as its raw materials feed. During the year, OM Group began construction of a carboxylates facility at Kokkola. Cobalt carboxylates are used by chemical processing, coatings, and tire industries.

Japan.—Sumitomo produced electrolytic cobalt, cobalt oxide, and cobalt salts as a byproduct of nickel production at its Niihama Nickel Refinery in Ehime Prefecture. Japanese cobalt capacity in table 6 was revised to reflect Sumitomo's current capacity. In addition, standby capacity for Nippon Mining Co. Ltd.'s nickel-cobalt refinery at Hitachi, Ibaraki Prefecture, was removed because Nippon no longer has the capacity to produce cobalt.

According to Japan's Ministry of International Trade and Industry (MITI), 1994 Japanese cobalt consumption increased 4% to 2,520 tons. Cobalt consumption by industry was reported as follows: cobalt in catalysts decreased 4% to 371 tons; cobalt in hard metal tools increased 8% to 299 tons; cobalt in magnetic materials decreased 11% to 486 tons; cobalt in specialty steels decreased 14% to 591 tons; cobalt in tube, plate, rod, and wire increased 18% to 275 tons; and cobalt in other uses increased 76% to 501 tons. Hitachi Metals Europe GmbH estimated total cobalt consumption, including chemical uses not covered by MITI, to increase 3% from 4,360 tons in 1993 to 4,580 tons in 1994.[17] Japan imported 5,650 tons of cobalt in 1994, a 41% increase over imports in 1993. Hitachi Metals estimated a stock buildup of nearly 1,000 tons in 1994.

Mexico.—International Curator Resources Ltd. of Vancouver, British Columbia, continued its investigation of the Boleo copper-cobalt property near Santa Rosalia, Baja California. The company estimated a combined drill-indicated and inferred resource of 140 million tons of ore containing 2 million tons of copper and 113,000 tons of cobalt.[18] Part of the deposit would be amenable to open pit mining. International Curator planned to continue the drilling program, mine planning, and metallurgical testwork to bring the project to feasibility stage in 1996 and production in 1997. Based on results to date, the company estimated an annual production of 50,000 tons of copper and 3,000 tons of cobalt.

New Caledonia.—Lateritic nickel ore from four mining companies in New Caledonia was exported to QNI's Yabulu nickel-cobalt refinery in Queensland, Australia, for processing. Nickel matte from Société Métallurgique Le Nickel's Doniambo smelter was sent to Eramet-SLN's refinery in Sandouville-LeHavre, France, where it was refined into nickel cathode, nickel chloride, and cobalt chloride. Inco continued to develop a hydrometallurgical process to treat lateritic ore from its Goro nickel-cobalt property in southern New Caledonia. The company planned to begin a feasibility study in 1995.

Norway.—The Falconbridge Nikkelverk refinery produced a record 2,820 tons of cobalt cathode in 1994,[19] a 17% increase from the 2,410 tons produced in 1993. Feedstock for the refinery was in the form of matte from company operations in Sudbury, Canada; BCL Ltd. in Botswana; and Norilsk Nickel in Russia. Since 1990, Falconbridge has gradually increased the Nikkelverk refinery's annual cobalt capacity from 2,000 tons to 2,900 tons.

Russia.—Russian cobalt continued to contribute to Western supply in 1994. Estimates of Russian cobalt exports in 1994 ranged from 1,000 tons to more than 3,500 tons. Estimates of 1994 production ranged from as low as 1,000 tons to more than 6,000 tons. Most of the cobalt produced in Russia is a byproduct of Russian nickel mining and/or refining. Nickel and cobalt production in Russia involves a complex flow of ores, concentrates, and mattes between various production sites. Russian nickel-cobalt production is organized into two "Complexes." Norilsk Nickel Complex's production is from nickel sulfide ores mined, smelted, and refined at Norilsk in Siberia and at various locations on the Kola Peninsula. In recent years, Norilsk Nickel has also toll-refined nickel and cobalt-bearing scrap and residues at its Monchegorsk refinery at Kola. Yuzhural Nickel Complex's smelters and refineries are in the Ural Mountains. Feedstock to Yuzhural Nickel's plants has included nickel laterites mined from the Ural region, cobalt-arsenide concentrates mined and beneficiated in the Tuva Autonomous Republic, nickel-cobalt sulfides from Cuba, and white alloy from Zaire.

South Africa, Republic of.—Cobalt was produced as a byproduct of South Africa's platinum industry. Two companies produced refined cobalt: Rustenburg Base Metal Refiners Pty. Ltd. produced cobalt sulfate and Impala Platinum Ltd. produced cobalt metal powder. A third company, Western

Platinum Ltd., produced nickel sulfate containing minor amounts of cobalt. According to South Africa's Minerals Bureau, 1994 refinery production increased to 258 tons, contained cobalt. Local cobalt sales increased 87% to 86 tons, contained cobalt, while exports decreased 9% to 179 tons, contained cobalt.

Uganda.—The Kasese Cobalt Co. Ltd., owned by Uganda's state-owned Kilembe Mines Ltd., Bureau de Récherches Geologiques et Minières (BRGM) of France, and Normandy Poseidon subsidiary La Source, continued to evaluate a process for the bacterial extraction of cobalt from pyrite concentrates stockpiled at the Kilembe copper mines. The studies confirmed that engineering designs based on the pilot plant at Kasese were feasible on a full plant scale. Construction of a bioleaching/solvent extraction/electrowinning plant was planned for early 1996. The plant was to have the capacity to produce 1,000 tons of cobalt cathode per year. Kasese Cobalt Co. anticipated that sufficient concentrates were available for 12 years of production.[20]

Zaire.—Gécamines reported a 50% increase in its cobalt production, from 2,200 tons in 1993 to 3,300 tons in 1994.[21] These production figures include cobalt contained in materials that require further refining. Detailed information on cobalt production by type was not available, so the amount of finished metal produced in 1994 was estimated. Gécamines produced primarily granules, low-quality Likasi cathode, alloys, and mattes. Only a small amount of high-quality cathode was produced. Both the quantity and quality of the cobalt produced were related to the type of feed materials processed. In 1994, the production of concentrates continued to be impacted by a lack of ore feed, so cobalt hydrates and other intermediate materials were the predominant feed to the refineries.[22]

Gécamines outlined the investment necessary to bring its mine production back to former levels. An estimated $60 million would be needed to rehabilitate the Kamoto Mine, which suffered a major mine collapse in 1990. The funds would be used to install an underground crusher to replace the one lost in the collapse, excavate access ramps to the new mining area, and reequip the mine. An additional $200 million per year would be needed over a 4-year period to remove overburden from open pit mines in Gécamines' Western Group. Past delays in overburden removal significantly impacted production from the open pit mines. Gécamines planned to have an in-pit rock-crushing plant and conveyor belt system for removal of overburden at the KOV open pit operational by mid-1995. Gécamines also stated the need to rehabilitate its concentrators and refineries, improve cobalt recovery rates at the concentrators and refineries, and maintain adequate supplies of consumables such as lime and acid for the refineries.

In October, Gécamines signed an agreement to sell a minimum of 15,000 metric tons of cobalt slag to OM Group. The slag would be processed at OM Group's Kokkola refinery in Finland.

Zambia.—ZCCM produced 2,640 tons of cobalt metal between January and December 1994, a decrease of 37% from the 4,210 tons produced in calendar year 1993.[23] The decrease in production was because ZCCM began treating low grade ore in 1993. In addition to the lower grade, the ore had a more complex mineralogy, which adversely affected the recovery rates at the concentrators. ZCCM expected to continue treating low grade ore until the fourth quarter of 1995, when high grade ore from the Nchanga open pit would become available.

ZCCM investigated various options for increasing production from existing operations. The company estimated that it could increase its cobalt production by 650 tons per year by improving the recovery rates at its cobalt plants. In addition, ZCCM estimated that an additional 2,000 tons of cobalt could be recovered each year from smelter slags.[24] Qasim Mining Enterprises Ltd. (QME) of Lusaka, Zambia, negotiated with ZCCM regarding the right to recover cobalt from some of the smelter slag stockpiled at Nkana. Colossal Resources Corp. of Vancouver, BC, agreed to finance the design and construction of a cobalt extraction plant in exchange for a 60% share in a joint venture with QME. Collosal was considering a two-stage process to recover the cobalt. The slag would be processed pyrometallurgically to produce a cobalt-copper-iron alloy, then the alloy would be refined hydrometallurgically to produce cobalt metal.

By yearend, the government of Zambia had not decided how to proceed with privatizing ZCCM. However, the government's relaxation of restrictions on prospecting resulted in a number of international mining companies expressing interest in prospecting and exploration in Zambia.

Outlook

The cobalt market continues to adjust to the loss of Zaire as the dominant supplier. Several cobalt refiners have steadily increased capacities and production levels. Sales of cobalt from the DLA and cobalt exports from Russia added to supply and helped to balance the market over the past few years. However, when the African producers lost their dominance in the market they also lost control of the price. As a result, cobalt prices have varied widely over the past few years in response to perceived imbalances between supply and demand.

The combined effect of high prices during 1994 and Zaire's inability to rapidly increase its output has opened up opportunities for new producers and for expanded production by current producers. In mid-1995, Ego Resources of Canada began producing cobalt as a primary product. Plans are also underway to produce primary cobalt in Uganda. Byproduct cobalt production is being considered at new mining projects in Australia, Canada, Mexico, New Caledonia, and Tanzania. Decisions on how to proceed with each project will depend on the markets for the primary metals to be produced, either nickel or copper.

High prices have made cobalt recovery from secondary and intermediate materials economically feasible. Cobalt slags from Zaire are being refined in Finland. The refining of Zambian slags is being evaluated. Some cobalt processors have shifted to using lower quality metal, intermediate, and/or secondary materials for the production of powders and salts, lessening the demand for high-grade cobalt metal.

World cobalt demand is expected to increase as the economies of the major consuming countries improve. However, the CDI points out that changes in technology and increases in recycling and economy of use since the late 1970's have dampened cobalt growth. The CDI estimates that cobalt consumption (excluding Russia) will remain at 23,000 tons plus or minus 2,000 tons. However, they point out that cobalt use in batteries, growth in developing geographic markets such as China and India, or a resurgence in consumption by former Soviet Union could increase future world consumption beyond that range.[25]

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TABLE 1
SALIENT COBALT STATISTICS 1/

(Metric tons cobalt content unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Consumption:					
Reported	7,520 r/	7,190 r/	6,370 r/	6,420 r/	6,870
Apparent	7,640	7,790	6,590 r/	7,310	8,400
Imports for consumption	6,530	6,920	5,760	5,950	6,780
Exports	1,340	1,540	1,420	795	1,360
Stocks, December 31 2/	1,850	1,620	840 r/	819 r/	926
Price: Metal, per pound					
Average U.S. spot cathode 3/	$10.09	$16.92	$22.93	$13.79	$24.66
Yearend producer 4/	$8.40	$11.00	$18.00	$18.00	$25.00
World: Production					
Mine	42,300 r/	32,500 r/	26,800 r/	20,600 r/	18,500 e/
Refinery	27,300	24,800	21,900	16,800 r/	18,500 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Stocks held by cobalt processors and consumers.

3/ Prices for 1990-92 are weighted averages of weekly prices reported by Metals Week; prices for 1993-94 are annual average prices reported by Platt's Metals Week.

4/ Price established by La Générale des Carrières et des Mines and Zambia Consolidated Copper Mines Ltd.

TABLE 2
U.S. REPORTED CONSUMPTION AND STOCKS OF COBALT 1/ 2/

(Metric tons cobalt content)

	1993	1994
Consumption by end use:		
Steel:		
Stainless and heat-resisting	41	28
Tool	59	81
Superalloys	2,530 r/	2,760
Alloys (excludes steels and superalloys):		
Magnetic alloys	569 r/	693
Welding materials (structural and hard-facing) 3/	255 r/	294
Other alloys 4/	95	99
Cemented carbides 5/	569	723
Chemical and ceramic uses:		
Catalysts	935	871
Drier in paint or related usage	732	809
Pigments	193	198
Miscellaneous and unspecified 6/	433	320
Total	6,420 r/	6,870
Consumption by form:		
Chemical compounds (organic and inorganic) 7/	2,040	2,000
Metal	2,810 r/	3,360
Purchased scrap	1,570	1,510
Total	6,420 r/	6,870
Stocks, December 31 8/		
Chemical compounds (organic and inorganic) 7/	307	292
Metal	354 r/	479
Purchased scrap	158	155
Total	819 r/	926

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes estimates.

3/ Includes wear-resistant alloys.

4/ Includes nonferrous alloys.

5/ Includes diamond bit matrices, cemented and sintered carbides, and cast carbide dies or parts.

6/ Includes feed or nutritive additive, full alloy steel, glass decolorizer, ground coat frit, and mill products made from metal powder.

7/ Includes oxides.

8/ Stocks held by cobalt processors and consumers.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY FORM 1/

(Metric tons unless otherwise specified)

		1993	1994
Metal: 2/			
Gross weight		5,390	5,890
Cobalt content 3/		5,390	5,890
Value	thousands	$166,000	$248,000
Oxides and hydroxides:			
Gross weight		444	763
Cobalt content 3/		320	549
Value	thousands	$12,600	$26,100
Other forms:			
Acetates:			
Gross weight		13	157
Cobalt content 3/		3	38
Value	thousands	$141	$1,760
Carbonates:			
Gross weight		57	93
Cobalt content 3/		26	43
Value	thousands	$980	$2,010
Chlorides:			
Gross weight		17	89
Cobalt content 3/		4	22
Value	thousands	$157	$815
Sulfates			
Gross weight		754	906
Cobalt content 3/		204	245
Value	thousands	$6,040	$7,560
Total:			
Gross weight		6,670	7,890
Cobalt content 3/		5,950	6,780
Value	thousands	$186,000	$286,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Unwrought cobalt, excluding alloys and waste and scrap.

3/ Estimated from gross weights.

Source: Bureau of the Census; minor adjustments by the U.S. Bureau of Mines.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY 1/

Country of origin	Metal 2/			Oxides and hydroxides			Other forms 3/			Total		
	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content 4/ (metric tons)	Value (thousands)
1993:												
Belgium	109	109	$6,290	158	114	$5,040	21	7	$306	288	230	$11,600
Brazil	--	--	--	--	--	--	2	(5/)	23	2	(5/)	23
Canada	790	790	23,200	20	14	449	13	6	222	823	810	23,900
China	--	--	--	2	1	76	--	--	--	2	1	76
Finland	433	433	16,300	158	114	4,080	784	217	6,600	1,370	764	26,900
France	37	37	3,110	6	4	383	--	--	--	43	41	3,490
Germany	120	120	7,680	--	--	--	(5/)	(5/)	2	120	120	7,680
Japan	2	2	198	18	13	221	(5/)	(5/)	5	21	15	423
Norway	1,090	1,090	32,500	--	--	--	--	--	--	1,090	1,090	32,500
Russia	539	539	14,500	4	3	82	20	6	141	562	548	14,700
South Africa, Republic of	41	41	1,270	--	--	--	--	--	--	41	41	1,270
United Kingdom	24	24	738	77	56	2,280	3	1	22	104	80	3,040
Zaire	627	627	21,400	--	--	--	--	--	--	627	627	21,400
Zambia	1,560	1,560	38,500	--	--	--	--	--	--	1,560	1,560	38,500
Other	22	22	712	--	--	--	--	--	--	22	22	712
Total	5,390	5,390	166,000	444	320	12,600	842	237	7,320	6,670	5,950	186,000
1994:												
Belgium	95	95	5,300	306	220	12,300	30	8	389	431	323	18,000
Canada	663	663	32,000	68	49	2,340	22	10	457	753	722	34,800
China	46	46	1,660	1	1	15	42	11	295	88	57	1,970
Finland	622	622	29,000	279	201	8,310	955	265	8,570	1,860	1,090	45,900
France	49	49	4,090	8	6	518	--	--	--	57	55	4,610
Germany	148	148	9,740	(5/)	(5/)	25	13	3	85	162	152	9,850
Japan	(5/)	(5/)	21	10	7	281	1	(5/)	12	11	8	314
Mexico	--	--	--	--	--	--	9	3	54	9	3	54
Netherlands	19	19	206	--	--	--	(5/)	(5/)	5	20	20	212
Norway	1,200	1,200	55,300	--	--	--	--	--	--	1,200	1,200	55,300
Russia	896	896	26,000	73	52	1,690	90	27	1,350	1,060	975	29,100
South Africa, Republic of	17	17	608	--	--	--	20	5	132	37	23	740
United Kingdom	64	64	2,330	17	13	572	62	15	799	144	92	3,700
Zaire	466	466	22,400	--	--	--	--	--	--	466	466	22,400
Zambia	1,580	1,580	58,700	--	--	--	--	--	--	1,580	1,580	58,700
Other	11	11	470	--	--	--	--	--	--	11	11	470
Total	5,890	5,890	248,000	763	549	26,100	1,250	347	12,100	7,890	6,780	286,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Unwrought cobalt, excluding alloys and waste and scrap.

3/ Cobalt sulfates, cobalt chlorides, cobalt carbonates, and cobalt acetates.

4/ Estimated from gross weights.

5/ Less than 1/2 unit.

Source: Bureau of the Census; minor adjustments by the U.S. Bureau of Mines.

TABLE 5
U.S. EXPORTS OF COBALT IN 1994, BY COUNTRY 1/ 2/

Country of destination	Metal 3/		Oxides and hydroxides		Acetates		Chlorides		Total	
	Gross weight (metric tons)	Value 4/ (thousands)	Gross weight (metric tons)	Value 4/ (thousands)	Gross weight (metric tons)	Value 4/ (thousands)	Gross weight (metric tons)	Value 4/ (thousands)	Cobalt content 5/ (metric tons)	Value 4/ (thousands)
Australia	1	$29	16	$419	--	--	--	--	13	$447
Belgium	60	898	--	--	--	--	--	--	60	898
Brazil	48	2,120	12	193	4	$41	--	--	58	2,350
Canada	183	5,180	10	221	2	18	1	$7	191	5,420
Chile	--	--	8	237	--	--	--	--	5	237
Colombia	--	--	8	270	(6/)	5	--	--	6	275
Finland	56	328	--	--	--	--	--	--	56	328
France	66	1,310	47	1,490	--	--	1	11	100	2,810
Germany	80	1,430	--	--	--	--	--	--	80	1,430
Hong Kong	2	81	8	291	--	--	--	--	8	372
India	5	70	--	--	6	86	--	--	6	155
Indonesia	15	702	--	--	--	--	--	--	15	702
Italy	2	109	8	228	3	120	--	--	8	457
Japan	334	13,800	33	780	--	--	--	--	357	14,600
Korea, Republic of	5	252	2	60	--	--	(6/)	3	6	315
Mexico	13	627	103	1,900	181	1,620	1	15	131	4,170
Netherlands	91	3,510	--	--	(6/)	8	--	--	91	3,520
Panama	--	--	(6/)	5	1	6	--	--	(6/)	12
Spain	--	--	--	--	36	262	--	--	9	262
Taiwan	5	167	34	743	38	375	9	114	41	1,400
Turkey	(6/)	4	--	--	15	99	--	--	4	103
United Kingdom	70	986	2	10	10	137	--	--	74	1,130
Venezuela	--	--	22	125	--	--	--	--	16	125
Other	18	860	15	445	--	--	--	--	29	1,300
Total	1,050	32,500	327	7,420	297	2,780	12	151	1,360	42,800

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ In addition to the materials listed, the United States exported cobalt ores and concentrates and wrought cobalt and cobalt articles.

3/ Includes unwrought cobalt, powders, waste and scrap, and mattes and other intermediate products of cobalt metallurgy.

4/ Free alongside ship (f.a.s.) value.

5/ Estimated from gross weights.

6/ Less than 1/2 unit.

Source: Bureau of the Census; minor adjustments by the U.S. Bureau of Mines.

TABLE 6
WORLD ANNUAL COBALT REFINERY CAPACITY, DECEMBER 31, 1994 1/

(Metric tons cobalt content)

Country	
Belgium 2/	1,200
Brazil	300
Canada 3/	3,900
China e/	500
Finland e/ 2/	3,000
France 4/	600
Japan 2/	480
Norway	2,900
Russia e/	8,000
South Africa, Republic of e/ 5/	750
United States 6/	900
Zaire	18,000
Zambia	5,000
Total	45,500

e/ Estimated.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to total shown.

2/ Includes oxide and salts.

3/ Includes oxide.

4/ Cobalt chloride.

5/ Includes sulfate.

6/ Standby capacity.

TABLE 7
COBALT: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, cobalt content)

Country 3/	1990	1991	1992	1993	1994 e/
Albania e/ 4/	600	600	20	10	10
Australia e/ 5/	1,200	1,400	1,600	1,700	2,100
Botswana 6/	205	208	208	205 r/	200
Brazil e/	400	400	400	400	400
Canada 7/	5,470	5,270	5,100	5,110 r/	4,330 8/
Cuba e/ 9/	1,460 r/	1,120 r/	1,150 r/	1,030 r/	1,000
Morocco 10/	194	325	461	397	440
New Caledonia e/ 11/	800	800	800	800	800
Russia e/ 12/	XX	XX	4,000	3,300	3,300
South Africa, Republic of e/	350	350 r/	350	350	350
U.S.S.R. e/ 12/ 13/	5,500	5,000	XX	XX	XX
Zaire 10/ 14/	19,000	9,900	5,700	2,460	2,000
Zambia 10/ 15/	7,000	6,990	6,910	4,750 r/	3,500
Zimbabwe e/ 16/	102	105	80	90 r/	100
Total	42,300 r/	32,500 r/	26,800 r/	20,600 r/	18,500

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 19, 1995. Figures represent recoverable cobalt content of ores, concentrates, or intermediate products from copper, nickel, platinum, or zinc operations. Morocco was the only country where cobalt was mined as a primary product.

3/ In addition to the countries listed, Bulgaria, China, Germany, Indonesia, and Poland are known to produce ores that contain cobalt, but information is inadequate for reliable estimates of output levels. Other copper-, nickel-, platinum-, or zinc-producting nations may also produce ores containing cobalt as a byproduct component, but recovery is small or nil.

4/ Calculated from reported and estimated weight of nickeliferous ore.

5/ Figures represent quantities of cobalt contained in intermediate metallurgical products (cobalt sulfide; nickel-cobalt sulfide, and nickel matte) produced from Australian and imported ores. Cobalt content of lateritic nickel ore, nickel concentrate, and zinc concentrate originating in Australia was estimated as follows, in metric tons: 1990–1,870; 1991–1,670; 1992–1,270; 1993–1,320 (revised); and 1994–1,270.

6/ Reported cobalt content of pelletized nickel-copper matte.

7/ Figures represent the assay content of cobalt in concentrates produced. The cobalt content of all products derived from ores of Canadian origins, including cobalt oxide shipped to the United Kingdom for further processing and nickel-copper-cobalt matte shipped to Norway for refining, was reported as follows, in metric tons: 1990–2,180; 1991–2,170; 1992–2,220; 1993–2,150 (revised); and 1994–1,920.

8/ Reported figure.

9/ Determined from reported nickel-cobalt content of sulfide production. Data not comparable with those prior to 1990.

10/ Cobalt content of concentrates.

11/ Series represents estimated recoverable content of ores and intermediate metallurgical products exported from New Caledonia to France. The estimated cobalt content of total ores mined is as follows, in metric tons: 1990–6,000; 1991–6,000; 1992–6,000; 1993-6,000; and 1994–6,000.

12/ All production in the U.S.S.R. from 1990-91 came from Russia.

13/ Dissolved in Dec. 1991.

14/ In addition to concentrates, cobalt hydrates and scrap are used as feed to the refineries. Cobalt content of these materials was as follows, in metric tons: Hydrates: 1990–3,190; 1991–5,480; 1992–4,110; 1993–1,000 (estimated); and 1994–4,000 (estimated). Scrap: 1990–49; 1991–517; 1992–1,110; 1993–180 (estimated); and 1994–not available.

15/ Fiscal years beginning Apr. 1 of that stated. Cobalt content of ore milled was as follows, in metric tons: 1990–10,900; 1991–11,000; 1992–11,400; 1993–9,480 (revised); and 1994–8,500 (estimated).

16/ Estimated cobalt content of ore.

TABLE 8
COBALT: WORLD REFINERY PRODUCTION, BY COUNTRY AND PRODUCT 1/ 2/

(Metric tons, cobalt content)

Country 3/	1990	1991	1992	1993	1994 e/
Albania: Oxide e/	20	15	3	1	--
Brazil: Metal e/	240	240	240	240	240
Canada: Metal (including metal powder and oxide)	2,060	2,250	2,210	2,700	2,950 4/
China: Metal e/	325	300	220	190 r/	200
Finland (metal powder and salts)	1,300	1,500	2,100	2,200	3,000 4/
France: Chloride	150	123	120 r/	144 r/	138 4/
Japan: Metal	199	185	105	191 r/	161 4/
Norway: Metal	1,830	1,980	2,290	2,410	2,820 4/
Russia: Unspecified e/ 5/	XX	XX	4,500	4,000	4,000
South Africa, Republic of:					
Metal (powder) e/	70	60	65	50	65
Sulfate e/	179	149	169	122	193
Total	249	209	234	172	258 4/
U.S.S.R.: Unspecified e/ 5/ 6/	6,300	5,100	XX	XX	XX
Zaire: Metal 7/	9,950	8,110	5,050	831	2,200 4/
Zambia: Metal 8/	4,670	4,740	4,800	3,710 r/	2,500
Total metal	19,300 r/	17,900 r/	15,000 r/	10,300 r/	11,100
Total salts 9/	349 r/	287 r/	292 r/	267 r/	331
Total unspecified	7,600 r/	6,600 r/	6,600 r/	6,200 r/	7,000
Grand total	27,300	24,800	21,900	16,800 r/	18,500

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 19, 1995. Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

3/ In addition to the countries listed, Belgium, Germany, and Slovakia may recover cobalt from imported materials, but production is not reported, and information is inadequate to make reliable estimates of production.

4/ Reported figure.

5/ All production in the U.S.S.R. from 1990-91 came from Russia.

6/ Dissolved in Dec. 1991.

7/ Excludes production of cobalt in white alloy, matte, and slag that would require further refining.

8/ Fiscal years beginning Apr. 1 of that stated.

9/ Includes oxide.

COLUMBIUM (NIOBIUM) AND TANTALUM

By Larry D. Cunningham

Columbium (Cb) is vital as an alloying element in steels and in superalloys for aircraft turbine engines and is in greatest demand in industrialized countries. Columbium is critical to the United States because of its defense-related uses in the aerospace, energy, and transportation industries. Acceptable substitutes are available for some columbium applications, but in most cases they are less desirable.

Tantalum (Ta) is a refractory metal that is ductile, easily fabricated, has a high melting point (2,996 °C), is highly resistant to corrosion by acids, and is a good conductor of heat and electricity. Tantalum is also critical to the United States because of its defense-related applications in aircraft, missiles, and radio communications. Substitution for tantalum is made at either a performance or economic penalty in most applications.

Domestic columbium and tantalum resources are of low grade. Some are mineralogically complex, and most are not currently commercially recoverable. The last significant mining of columbium and tantalum was during the Korean conflict when increased military demand resulted in columbium and tantalum ore shortages.

In 1994, the United States continued to be dependent on imports of columbium and tantalum materials. Brazil continued as the major source for columbium imports, and Australia continued as the major source for tantalum imports. Columbium price quotations were unchanged for the year, and tantalum price quotations remained stable.

The President of the United States granted General System of Preferences (GSP) status to Kazakhstan, Ukraine, and the Republic of South Africa.

Overall reported consumption of columbium in the form of ferrocolumbium and nickel columbium continued to increase, with demand for columbium in superalloys up significantly. Overall demand for tantalum was at the highest level since 1984.

Legislation and Government Programs

The high degree of import reliance for columbium and tantalum is the principal strategic problem faced by the United States. Summaries of important columbium and tantalum statistics are shown in tables 1 and 2, respectively. *(See tables 1 and 2.)*

To ensure a supply of columbium and tantalum during an emergency, goals for both materials have been established for the National Defense Stockpile (NDS). However, inventories for both materials are substantially under set goals. As of September 30, 1994, NDS overall goal for the columbium group was 5.05 million kilograms, and the overall goal for the tantalum group was 3.96 million kilograms. *(See table 3.)*

On December 8, 1994, the President signed legislation adopting the Uruguay Round accords of the General Agreements on Tariffs and Trade (GATT) which included renewal of the GSP program until July 31, 1995. The GSP program had expired on September 30, 1994. The legislation extending the GSP was retroactive to September 30. Under GSP, the United States grants duty-free access to goods from more than 140 developing countries and territories. In 1994, U.S. imports for columbium and tantalum products ranged from duty free to 5.5% ad valorem for most-favored-nation (MFN) status and from duty free to 45% ad valorem for non-MFN status.

In Proclamation 6650 of February 16, 1994, the President of the United States designated Kazakhstan as a beneficiary developing country for purposes of the GSP, effective March 4, 1994. In Proclamation 6655 of March 3, 1994, the President also granted GSP status to Ukraine, effective March 23, 1994. Kazakhstan and Ukraine join Russia, October 1993, as republics in the former U.S.S.R. with GSP status. The extension of GSP status is part of the Administration's overall effort to facilitate Kazakhstan and Ukraine's transformation to free market economies. Additionally, GSP status was granted to the Republic of South Africa in Proclamation 6676 of April 21, 1994, effective May 10, 1994.

In August, it was reported that the Department of Energy (DOE) and the State of Texas had resolved Texas's claim for reimbursement of its contributions to DOE's Superconducting Super Collider (SSC), particle accelerator, project. In October 1993, Congress had voted to close down the SSC project which was under construction in Waxachachie, TX. Terms of the settlement reportedly call for a $145 million payment to Texas, a $65 million contribution toward completion of a regional medical facility, and a release by Texas of all future claims against the United States.[1]

In April, it was reported that the Defense Reutilization and Marketing Service (DRMS) sold 1,315 kilograms of tantalum scrap, guided missile components, to Charter Trading Ltd., Chicago, IL, at a price of $57.34 per kilogram ($26.011 per pound).[2]

Production

Domestic production data for ferrocolumbium are developed by the U.S. Bureau of Mines from the annual voluntary domestic survey for ferroalloys. Of the four operations to which a survey request was sent, two responded. Thus, ferrocolumbium production data for 1994 were incomplete at the time this report was prepared.

Although there was no domestic mineral production of either columbium or tantalum in 1994, there were two processors of columbium- and tantalum-bearing source materials that were integrated from raw material processing to columbium and tantalum end products. They were Cabot Corp. for columbium and tantalum processing and Shieldalloy Metallurgical Corp., dedicated solely to columbium processing. Hermann C. Starck Inc. was a major supplier of tantalum and columbium products, and Thai Tantalum Inc. produced tantalum products. Reading Alloys Inc. and Teledyne Wah Chang Albany were major producers of high-purity columbium products. Kennametal Inc. was the major producer of columbium and tantalum carbides.

Consumption

Overall reported consumption of columbium as ferrocolumbium and nickel columbium rose by more than 10% compared with that of 1993. *(See table 4.)* Consumption of columbium by the steelmaking industry increased by about 8%, affected by a 3% increase in raw steel production and a 5% increase in the percentage of columbium usage per ton of steel produced. Columbium consumption in carbon and stainless and heat-resisting steels were both up by more than 10%, while columbium consumption in high-strength low-alloy steel was up modestly. Demand for columbium in superalloys increased to more than 400,000 kilograms, the highest level since 1991. That portion used in the form of nickel columbium rose to more than 260,000 kilograms.

Overall consumption of tantalum rose to about 430,000 kilograms, the highest level since 1984, aided mostly by increased consumption of capacitor-grade tantalum powder in the electronics sector. The Electronic Industries Association reported that factory sales of tantalum capacitors were up by about 30%, a twofold increase compared with sales in 1990. However, the amount of tantalum capacitor-grade powder consumed per capacitor continued to decline, owing to the trend toward higher capacitance tantalum powders and capacitor miniaturization.

Columbium.—Columbium and niobium are synonymous names for the chemical element with atomic number 41; columbium was the first name given, and niobium was the name officially designated by the International Union of Pure and Applied Chemistry in 1950. The metal conducts heat and electricity relatively well, has a high melting point (2,480 °C), is readily fabricated, and is highly resistant to many chemical environments.

Columbium, in the form of ferrocolumbium, is used worldwide, principally as an additive to improve the strength and corrosion resistance of steel. Because of its refractory nature, appreciable amounts of columbium in the form of high-purity ferrocolumbium and nickel columbium are used in nickel-, cobalt-, and iron-base superalloys for applications such as jet engine components, rocket subassemblies, and heat-resisting and combustion equipment. Columbium carbide is used in cemented carbides to modify the properties of the cobalt-bonded tungsten carbide-based material. It is usually used with carbides of metals such as tantalum and titanium. Columbium oxide is the intermediate product used in the manufacture of high-purity ferrocolumbium, nickel columbium, columbium metal, and columbium carbide.

Tantalum.—The major end use for tantalum, as tantalum metal powder, is in the production of electronic components, mainly tantalum capacitors. Applications for tantalum capacitors include computers, communication systems, and instruments and controls for aircraft, missiles, ships, and weapon systems. The tantalum capacitor exhibits reliable performance and combines compactness and high efficiency with good shelf-life. Because of its high melting point, good strength at elevated temperatures, and good corrosion resistance, tantalum is combined with cobalt, iron, and nickel to produce superalloys that are employed in aerospace structures and jet engine components. Tantalum carbide, used mostly in mixtures with carbides of such metals as columbium, titanium, and tungsten, is used in cemented-carbide cutting tools, wear-resistant parts, farm tools, and turning and boring tools. Because of its excellent corrosion-resistant properties, tantalum mill and fabricated products are used in the chemical industry in applications such as heat exchangers, evaporators, condensers, pumps, and liners for reactors and tanks.

Prices

A published price for pyrochlore concentrates produced in Brazil and Canada was not available. A price for Brazilian pyrochlore has not been available since 1981, and the published price for Canadian pyrochlore was suspended in early 1989. However, the Platt's Metals Week published price for regular-grade ferrocolumbium, produced from pyrochlore concentrates, was $6.58 per pound of contained columbium, f.o.b. shipping port.

The Metal Bulletin published price for columbite ore, on the basis of a minimum 65% contained Cb_2O_5 and Ta_2O_5, remained unchanged at a range of $2.40 to $2.80 per pound. For the year, the Metals Week published price for columbium oxide was quoted at $8.17 per pound of oxide; the published price for high-purity ferrocolumbium containing 62% to 68% columbium was quoted at $18.50 per pound of contained columbium, f.o.b. shipping point; the published price for nickel columbium was quoted at $20.50 per pound of contained columbium; and the published price for columbium metal was quoted at a range of $30 to $50.

The Metals Week published spot price for tantalite ore, on the basis of contained Cb_2O_5 and Ta_2O_5, c.i.f. U.S. ports, quoted since March 1993 at a range of $25.50 to $26.50 widened to $25.50 to $27 in mid-January, where it remained through December. The Metal Bulletin published price for tantalite fell from a range of $28 to $32 per pound of contained Ta_2O_5 to a range of $26 to $30 in April, where it remained through December. For the year, the Metal Bulletin published price for tantalite produced by Greenbushes Ltd. of Australia on the basis of 40% contained Ta_2O_5 was quoted at $40 per pound. A published price for tantalite from the Canadian producer, Tanco, was not available. Industry sources indicated that tantalum mill products sold at an average of about $170 per pound, depending on specification, and that tantalum capacitor-grade powder sold at an average of about $145 per pound.

A published price for columbium and tantalum carbide was not available.

Foreign Trade

Data for exports and imports are summarized in table 5. Net trade for columbium and tantalum continued at a deficit. Overall trade value for exports was up by 5%, with total volume down by 8%. For imports, trade value and volume were up by more than 20%. *(See table 5.)*

Imports for consumption of columbium mineral concentrates increased by about 30%. Canada continued as the leading supplier, providing most of both total quantity and total value. *(See table 6.)*

Imports at an average grade of approximately 60% Cb_2O_5 and less than 1% Ta_2O_5 were estimated to contain 1.29 million kilograms of columbium and a small quantity of tantalum.

Imports for consumption of tantalum mineral concentrates were down by more than 10%, with the average unit value for overall imports down by 8%. Imports from Australia and Brazil, producing countries, accounted for more than 50% of total quantity and more than 60% of total value. *(See table 7.)* Imports at an average grade of approximately 34% Ta_2O_5 and 24% Cb_2O_5 were estimated to contain 310,000 kilograms of tantalum and 190,000 kilograms of columbium.

Imports for consumption of synthetic tantalum-columbium concentrates totaled 25,000 kilograms valued at $160,000 compared with 36,000 kilograms valued at $912,000 in 1993. These figures are not included in the salient statistics data.

The schedule of applied tariffs during 1994 to U.S. imports of selected columbium and tantalum materials is found in the U.S. International Trade Commission's (USITC's) 1994 Harmonized Tariff Schedule of the United States, USITC Publication 2690. Brazil continued as the major source for U.S. columbium imports, accounting for more than 60% of the total, and Australia remained the major source for U.S. tantalum imports, accounting for more than 30% of the total. *(See figures 1 and 2.)*

World Review

Industry Structure.—Principal world columbium and tantalum raw material and product producers are shown in tables 8 and 9, respectively. Brazil and Canada remained the major producers of columbium raw materials feedstock, while tantalum raw materials continued to be produced mainly in Australia, Brazil, and Canada and in Thailand in the form of high-grade tantalum-bearing tin slags. Annual world production of columbium and tantalum mineral concentrates, by country, is given in table 10.. *(See tables 8, 9, and 10.)*

Australia.—For its fiscal year ending June 30, 1994, Gwalia Consolidated Ltd. reported that sales of tantalum oxide produced in tantalum concentrates at its Greenbushes Mine, southwest Western Australia, was about 153 tons compared with about 130 tons the previous year. Gwalia continues as the world's largest producer of tantalum concentrates, with contractual relationships with the two largest processors of tantalum concentrates in Germany and North America. The tantalum processing plant at the Greenbushes Mine has an annual ore throughput capacity of about 850,000 tons, and the company indicates that the plant will operate at this capacity for the foreseeable future.[3]

Brazil.—Cia. Brasileira de Metalurgia e Mineracao (CBMM) was reported to have installed a new electric furnace to produce ferrocolumbium at its facility in Araxa. Since 1991, CBMM had relied on a semicontinuous autothermic reduction process to produce ferrocolumbium, which subsequently was put on stand by status. The electric furnace process will have an initial annual ferrocolumbium capacity of about 19,500 tons, operating at 260 days per year. CBMM plans to increase this capacity to about 28,000 tons annually.[4]

Canada.—As reported by Teck Corp., production of Cb_2O_5 at the Niobec Mine at St. Honoré, Quebec, decreased to about 3.3 million kilograms. Niobec is a 50-50 joint venture between Teck, operator, and Cambior Inc., product marketing. Ore milled was 809,000 tons, as the mill operated on the average of 2,210 tons of ore per day. Average recovery was 59.2% with Cb_2O_5 grade of concentrate at 69%. Teck reported that mine ore reserves are sufficient for another 12 years. Late in the year, operations commenced at the newly constructed ferrocolumbium plant at the Niobec minesite. First deliveries of ferrocolumbium to customers began in December. The mine is budgeted to produce about 3.4 million kilograms of ferrocolumbium in 1995. Starting early in the year, the plan is to convert all columbium concentrates produced at the mine to ferrocolumbium.[5]

Since midyear 1992, tantalum mining at the Bernic Lake, Manitoba, tantalum operation of Tantalum Mining Corp. of Canada Ltd. has remained suspended. However, an estimated 34,000 kilograms of contained tantalum oxide was produced from tailings retreatment.

Japan.—According to The Tex Report, Japan's production of ferrocolumbium decreased to 947 tons from the 1,210 tons reported in 1993. Columbium ore imported for ferrocolumbium production totaled 1,480 tons, with Canada accounting for over 90% of the total. As reported by Japan Metal Journal, ferrocolumbium imports totaled about 3,640 tons, with most of the imports coming from Brazil.

Roskill's Letter from Japan reported that Japan's demand for tantalum, in the form of powder, compounds, and products, was 255 tons compared with 225 tons in 1993. Japan's production of tantalum capacitors was 4.6 billion units compared with 4.61 billion units in 1993. In 1995, the demand for tantalum capacitors is forecast to increase markedly, with the main area of growth being in portable telephones.

Outlook

Columbium.—Columbium is used principally as an additive in steelmaking, which annually accounts for more than 80% of U.S. reported consumption. No significant change to this trend is expected in the near term because there are few other significant growth markets and/or uses for columbium. Thus, future columbium demand growth will continue to be directly related to the worldwide performance of the steel industry. The reader is referred to the outlook section of the Iron and Steel Annual Mineral Industry Surveys for discussion on the outlook for the steel industry. Additionally, Metal Bulletin reported that some leading industry sources anticipate that western world steel production and consumption will increase through the year 2000. However, steel demand in countries of the former U.S.S.R. will continue to decline owing to economic problems in those countries. The outlook for columbium also will be dependent to a lesser degree on the performance of the aerospace industry. Future growth for this end use will be affected mainly by the demand for columbium-containing superalloys by the aircraft industry.

Tantalum.—For the past decade, more than 60% of the tantalum consumed in the United States has been used to produce electronic components, mainly tantalum capacitors. In 1994, U.S. factory sales of tantalum capacitors was again at an alltime high, an increase of more than 100% over that in 1990. However, overall tantalum demand growth in this sector continued to be slowed owing to the industry's emphasis on higher capacitance powders and the miniaturization of electronic components resulting in less tantalum used per unit. Industry sources indicate that the growth of tantalum capacitors, mainly chip-type, will continue with a modest increase in the demand for tantalum capacitor-grade powder. Tantalum demand in the cemented carbide sector also is expected to experience modest growth. However, the demand for tantalum in this sector will continue to be affected by the use of coatings, which prolong tool life, and the replacement of cemented carbide tools with ceramics and silicon-nitride-based cutting tools.[6]

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[1] Chemical and Engineering News. V. 72, No. 31, Aug. 1, 1994, p. 25.

[2] American Metal Market. V. 102, No. 68, Apr. 11, 1994, p. 9.

[3] Gwalia Consolidated Ltd. 1994 Annual Report. 64 pp.

[4] The Tex Report. V. 26, No. 6162, July 21, 1994, p. 1.

[5] Teck Corp. 1994 Annual Report. 60 pp.

[6] Tantalum-Niobium International Study Center. Bulletin No. 80, Dec. 1994, 6 pp.

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TABLE 1
SALIENT COLUMBIUM STATISTICS 1/

(Thousand kilograms of columbium content unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Mine production of columbium-tantalum concentrates	(2/)	(2/)	(2/)	--	--
Releases from Government excesses	--	--	--	--	--
Production of ferrocolumbium	NA	NA	NA	NA	NA
Exports: Columbium metal, compounds, alloys (gross weight)	NA	NA	NA	NA	NA
Imports for consumption:					
Mineral concentrates e/	1,130	1,160	1,230	1,210	1,480
Columbium metal and columbium-bearing alloys e/	2	1	1	111	172
Ferrocolumbium e/	1,900	2,130	2,450	2,190	2,590
Tin slag	NA	NA	NA	NA	NA
Consumption:					
Raw materials	NA	NA	NA	NA	NA
Ferrocolumbium and nickel columbium e/	2,590	2,410	2,470	2,470 r/	2,750
Apparent	3,360	3,310	3,500	3,500	3,700
Prices:					
Columbite, dollars per pound 3/	3.25	2.83	2.83	2.67	2.60
Pyrochlore, dollare per pound 4/	2.75	2.75	2.75	2.75	NA
World: Production of columbium-tantalum concentrates e/	15,300 r/	15,700 r/	15,300 r/	12,400 r/	15,200

e/ Estimated. r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ A small unreported quantity was produced.

3/ Average value, contained pentoxides for material having a columbium pentoxide to tantalum pentoxide ratio of 10 to 1.

4/ Average value, contained pentoxide.

TABLE 2
SALIENT TANTALUM STATISTICS

(Thousand kilograms of tantalum content unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Mine production of columbium-tantalum concentrates	(1/)	(1/)	(1/)	--	--
Releases from Government excesses	--	--	--	--	--
Exports:					
Tantalum ores and concentrates (gross weight) 2/	1	11	17	11	23
Tantalum metal, compounds, alloys (gross weight)	161	219	136	235	242
Tantalum and tantalum alloy powder (gross weight)	82	66	61	57	46
Imports for consumption:					
Mineral concentrates e/	299	340	420	390	310
Tantalum metal and tantalum-bearing alloys 3/	21	19	14	67	73
Tin slag	NA	NA	NA	NA	NA
Consumption:					
Raw materials	NA	NA	NA	NA	NA
Apparent	390	370	375	410	430
Prices:					
Tantalite, dollars per pound 4/	31.17	30.06	28.19	26.41	26.24
World: Production of columbium-tantalum concentrates e/	396 r/	477	399 r/	310 r/	325

e/ Estimated. r/ Revised. NA Not available.

1/ A small unreported quantity was produced.

2/ Includes reexports.

3/ Exclusive of waste and scrap.

4/ Average value, contained tantalum pentoxides.

TABLE 3
COLUMBIUM AND TANTALUM MATERIALS IN GOVERNMENT INVENTORIES AS OF DECEMBER 31, 1994 1/

(Thousand kilograms of columbium or tantalum content)

Material	Stockpile goals	Disposal authority	National Defense Stockpile inventory			
			Uncommitted 2/			Committed
			Stockpile-grade	Nonstockpile-grade	Total	
Columbium:						
Concentrates	--	--	520	344	864	--
Carbide powder	--	--	10	--	10	--
Ferrocolumbium	--	--	271	151	422	--
Metal	--	--	7	--	7	--
Total	5,050 3/	--	808	495	1,300	--
Tantalum:						
Minerals	--	--	761	460	1,220	--
Carbide powder	--	--	13	--	13	--
Metal 4/	--	--	73	(5/)	73	--
Total	3,960 3/	--	847	460	1,310	--

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The stockpile also contained uncommitted inventories of 26,000 kilograms in columbium concentrates, 113,000 kilograms in ferrocolumbium, 37,000 kilograms in tantalum minerals, 46,000 kilograms in tantalum metal, and 74,000 kilograms in tantalum oxide with status (inventory) not yet determined.

3/ Overall goals for the columbium and tantalum groups as of Sept. 30, 1994.

4/ Capacitor grade.

5/ 45 kilograms.

Source: Defense Logistics Agency, Defense National Stockpile Center.

TABLE 4
CONSUMPTION, BY END USE, AND INDUSTRY STOCKS OF FERROCOLUMBIUM AND NICKEL COLUMBIUM IN THE UNITED STATES 1/

(Kilograms of contained columbium 2/)

End use	1993	1994
Steel:		
Carbon	819,000	920,000
Stainless and heat-resisting	317,000	350,000
Full alloy	(3/)	(3/)
High-strength low-alloy	1,020,000	1,050,000
Electric	--	--
Tool	(4/)	(4/)
Unspecified	5,960	9,450
Total	2,160,000	2,330,000
Superalloys	294,000	411,000
Alloys (excluding alloy steels and superalloys)	(5/)	(5/)
Miscellaneous and unspecified	17,500 r/	8,840
Total consumption	2,470,000 r/	2,750,000
STOCKS		
Dec. 31:		
Consumer	NA	NA
Producer 6/	NA	NA
Total stocks	NA	NA

r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes columbium and tantalum in ferrotantalum-columbium, if any.

3/ Included with "Steel: High-strength low alloy."

4/ Included with "Steel: Unspecified."

5/ Included with "Miscellaneous and unspecified."

6/ Ferrocolumbium only.

TABLE 5
U.S. FOREIGN TRADE IN COLUMBIUM AND TANTALUM METAL AND ALLOYS, BY CLASS 1/

(Thousand kilograms, gross weight, and thousand dollars)

Class	1993		1994		Principal destinations and sources, 1994
	Quantity	Value	Quantity	Value	
EXPORTS 2/					
Columbium:					
Ores and concentrates	6	$46	489 3/	$4,500	Netherlands 477, $4,380; Germany 8, $78; Taiwan 4, $25; Korea, Republic of (4/), $10; India (4/), $9.
Ferrocolumbium	815	7,310	234	2,080	Canada 151, $1,260; Mexico 74, $739; Netherlands 3, $57; Brazil 5, $12; Italy (4/), $9.
Tantalum:					
Synthetic concentrates	-	--	2	9	All to Singapore.
Ores and concentrates	11	111	23 3/	319	Brazil 18, $196; Latvia 4, $84; Netherlands 2, $39.
Unwrought and waste and scrap	177	5,010	146	6,610	Germany 34, $3,060; Hong Kong 83, $1,210; Canada 13, $949; United Kindom 7, $620; Japan 4, $456.
Unwrought powders	57	17,500	46	12,800	United Kingdom 13, $4,630; France 15, $4,120; Germany 9, $ 2,640; Japan 2, $588; Austria 4, $453; Australia 2, $162.
Unwrought alloys and metal	8	2,390	8	1,670	Canada 3, $766; Barbados 1, $399; France (4/), $152; Singapore (4/), $142; Germany 3, $105.
Wrought	50	18,700	88	25,600	Japan 29, $11,700; United Kingdom 11, $4,110; Germany 13, $3,280; Canada 25, $2,870; France 7, $2,380.
Total	XX	51,000	XX	53,600	Japan $12,700; United Kingdom $9,400; Germany $9,200; France $6,700; Canada $5,800.
IMPORTS FOR CONSUMPTION					
Columbium:					
Ores and concentrates	2,350	8,610	3,080	11,400	Canada 3,070, $11,300; Thailand 9, $136.
Oxide	301	5,390	757	11,600	Brazil 431, $6,060; Germany 136, $4,260; Russia 161, $938; Thailand 29, $353.
Ferrocolumbium	3,370	29,000	3,980	34,000	Brazil 3,970, $33,600; Germany 18, $336.
Unwrought alloys, metal, and powder	111	2,380	171	3,770	Germany 63, $1,220, Brazil 47, $1,090; Kazakhstan 25, $690; Russia 27, $588; Ukraine 7, $91; United Kingdom 5, $61.
Tantalum:					
Synthetic concentrates	36	912	25	160	Zimbabwe 16, $115; Hong Kong 9, $45.
Ores and concentrates	1,260	31,800	1,090	25,400	Australia 410, $12,500; Brazil 162, $3,340; Burundi 122, $2,690; China 116, $2,080; Rwanda 72, $1,400; Thailand 100, $1,100.
Unwrought waste and scrap	101	4,270	268	13,600	Germany 54, $4,120; Japan 45, $3,440; Mexico 78, $1,770; Hong Kong 23, $1,520; United Kingdom 24, $973; Russia 13, $796.
Unwrought powders	56	9,460	60	10,700	Thailand 30, $6,270; Germany 20, $2,530; China 8, $1,650; Japan 1, $103; Estonia 1, $69; Netherlands 1, $39.
Unwrought alloys and metal	8	1,040	12	1,790	Germany 10, $1,220; Japan 1, $437; Kazakhstan 1, $102; United Kingdom (4/), $15; The Czech Republic (4/), $6.
Wrought	3	547	1	368	Japan 1, $153; Switzerland (4/), $81; Austria (4/), $66; Germany (4/), $37; United Kingdom (4/), $22; Canada (4/), $9.
Total	XX	93,400	XX	113,000	Brazil $44,300; Germany $13,700; Australia $12,500; Canada $11,800; Thailand $7,900.

XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ For columbium, data on exports of metal and alloys in unwrought and wrought form, including waste and scrap, are not available; included in nonspecific tariff classificati

3/ All or part of these data have been referred to the Bureau of the Census for verification.

4/ Less than 1/2 unit.

Sources: Bureau of the Census and U.S. Bureau of Mines.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF COLUMBIUM MINERAL CONCENTRATES, BY COUNTRY 1/

(Thousand kilograms and thousand dollars)

Country	1993 Gross weight	1993 Value	1994 Gross weight	1994 Value
Belgium 2/	10	151	--	--
Canada	2,220	7,970	3,070	11,300
Germany 2/	73	347	--	--
Nigeria	47	146	--	--
Thailand	--	--	9	136
Total	2,350	8,610	3,080	11,400

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Presumably country of transshipment rather than original source.

Sources: Bureau of the Census and U.S. Bureau of Mines.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF TANTALUM MINERAL CONCENTRATES, BY COUNTRY 1/

(Thousand kilograms and thousand dollars)

Country	1993 Gross weight	1993 Value	1994 Gross weight	1994 Value
Australia	440	14,600	410	12,500
Austria 2/	5	181	--	--
Belgium 2/	--	--	26	727
Bolivia	2	43	--	--
Brazil	135	3,190	162	3,340
Burundi	50	1,060	122	2,690
Canada	40	830	19	420
China	32	602	116	2,080
Estonia	7	305	--	--
Germany 2/	146	3,190	--	--
Japan 2/	40	2,970	--	--
Kazakhstan	--	--	17	182
Namibia	1	43	--	--
Nigeria	66	171	5	142
Rwanda	193	3,000	72	1,400
Singapore 2/	--	--	6	99
Spain	6	99	9	162
Thailand	45	615	100	1,100
Zaire	48	898	10	181
Zimbabwe	--	--	15	322
Total	1,260	31,800	1,090	25,400

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add totals shown.

2/ Presumably country of transshipment rather than original source.

Sources: Bureau of the Census and U.S. Bureau of Mines.

TABLE 8
PRINCIPAL WORLD COLUMBIUM AND TANTALUM RAW MATERIAL PRODUCERS

Country	Company and/or mine	Material type
MINING OF COLUMBIUM- AND TANTALUM-BEARING ORES		
Australia	Gwalia Consolidated Ltd. (Greenbushes)	Columbium-tantalum.
	Pan West Tantalum Pty. Ltd. (Wodgina)	Tantalum.
Brazil	Cia. Brasileira de Metalurgia e Mineracao (CBMM) (Araxa)	Columbium.
	Cia. de Estanho Minas Brasil (MIBRA) 1/	Columbium-tantalum.
	Paranapanema S.A. Mineracao Indústria e Construcao (Pitinga)	Columbium-tantalum.
	Mineracao Catalao de Goiás S.A. (Catalao)	Columbium.
Canada	Cambior/Teck Corp. (Niobec)	Columbium.
	Tantalum Mining Corp. of Canada Ltd. (Tanco) 2/	Tantalum.
China	Government-owned	Columbium-tantalum.
PRODUCTION OF COLUMBIUM- AND TANTALUM-BEARING TIN SLAGS		
Australia	Gwalia Consolidated Ltd. (Greenbushes).	
Brazil	Cia. Industrial Fluminense. 1/	
	Mamoré Mineracao e Metalurgia. 3/	
Malaysia	Malaysia Smelting Corp. Sdn. Bhd.	
Thailand	Thailand Smelting and Refining Co. Ltd. (Thaisarco).	
PRODUCTION OF COLUMBIUM- AND TANTALUM-BEARING SYNTHETIC CONCENTRATES		
Germany:		
Western states	Gesellschaft Für Elektrometallurgie mbh (GFE). 1/	
	Hermann C. Starck Berlin KG.	

1/ A wholly owned subsidiary of Metallurg Inc., New York, NY.

2/ A wholly owned subsidiary of Cabot Corporation.

3/ A subsidiary of Paranapanema S.A. Mineracao Indústria e Construcao.

TABLE 9
PRINCIPAL WORLD PRODUCERS OF COLUMBIUM AND TANTALUM PRODUCTS

Country	Company	Products 1/
Austria	Treibacher Chemische Werke AG	Cb and Ta oxide/carbide, FeCb, NiCb.
Brazil	Cia. Brasileira de Metalurgia e Mineracao (CBMM)	Cb oxide/metal, FeCb, NiCb.
	Cia. Industrial Fluminense 2/	Cb and Ta oxide, Ta carbide.
	Mineracao Catalao de Goias S.A. (Catalao)	FeCb.
Germany:		
Western states	Gesellschaft Fur Elektrometallurgie mbH (GFE) 2/	FeCb, NiCb.
	Hermann C. Starck Berlin KG	Cb and Ta oxide/metal/carbide, K-salt, FeCb, NiCb, Ta capacitor powder.
Japan	Japan Metals & Chemicals Co. Ltd.	FeCb.
	Mitsui Mining & Smelting Co.	Cb and Ta oxide/metal/carbide.
	Showa Cabot Supermetals 3/	Ta capacitor powder.
	Hermann C. Starck-V Tech Ltd. 4/	Ta capacitor powder.
Kazakhstan	Ulba Metallurgical	Ta oxide, Ta metal.
Russia	Solikamsk Magnesium Works	Cb and Ta oxide, Cb and Ta metal.
United Kingdom	London & Scadinavian Metallurgical Co. Ltd. 2/	Cb and Ta carbide.
United States	Cabot Corp.	Cb and Ta oxide/metal, K-Salt, FeCb, NiCb, Ta capacitor powder.
	Hermann C. Starck Inc. 5/	Cb and Ta metal, Ta capacitor powder.
	Kennametal, Inc.	Cb and Ta carbide.
	Reading Alloys, Inc.	FeCb, NiCb.
	Shieldalloy Metallurgical Corp. 2/	FeCb, NiCb.
	Teledyne Wah Chang Albany	Cb oxide/metal, FeCb, NiCb.
	Thai Tantalum Inc.	Ta capacitor powder.

1/ Cb, columbium; Ta, tantalum; FeCb, ferrocolumbium; NiCb, nickel columbium; K-salt, potassium fluotantalate; oxide, pentoxide.

2/ A wholly owned subsidiary of Metallurg Inc., New York.

3/ A joint venture between Showa Denko and Cabot Corp.

4/ A subsidiary of Hermann C. Starck Berlin KG.

5/ Jointly owned by Bayer USA. and Hermann C. Starck Berlin KG.

TABLE 10
COLUMBIUM AND TANTALUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY 1/ 2/

(Thousand kilograms)

	Gross weight 4/					Columbium content 5/					Tantalum content 5/				
Country 3/	1990	1991	1992	1993	1994 e/	1990	1991	1992	1993	1994	1990	1991	1992	1993	1994
Australia: Columbite-tantalite	529	703	656	495	700	69	94	69	50	81	165	218	224	170	238
Brazil:															
Columbite-tantalite	310	290 e/	200 e/	175 e/	175	71	66	45	40	40	90	84	60	50	50
Pyrochlore	29,400	30,500	29,600	22,700 r/	30,300	12,300	12,800	12,500	9,540 r/	12,700	--	--	--	--	--
Canada:															
Pyrochlore	5,270	5,230	5,100	5,320	5,130	2,370	2,350	2,300	2,390	2,310	--	--	--	--	--
Tantalite e/	350	380	200	100 r/	120	14	15	8	5	6	86	93	48	25 r/	28
Malaysia: Columbite-tantalite	4	--	--	--	--	1	--	--	--	--	(6/) r/	--	--	--	--
Namibia: Tantalite	4	(6/)	(6/)	-- r/	--	1	(6/)	(6/)	-- r/	--	1	(6/)	(6/)	-- r/	--
Nigeria: Columbite	44	36	40 e/	40 e/	40	18	15	17	17	17	2	2	2	2	2
Rwanda: Columbite-tantalite	110	100 e/	100 e/	100 e/	10	33	30	30	30	3	24	22	22	22	2
South Africa, Republic of:															
Columbite-tantalite	(6/)	(6/)	(6/)	(6/)	-- 7/	(6/) e/	(6/) e/	(6/) e/	(6/) e/	-- 7/	(6/) e/	(6/) e/	(6/) e/	(6/) e/	-- 7/
Spain: e/ Tantalite	10	8	8	6	6	NA	NA	NA	NA	--	3	2	2	2	2
Thailand: Columbite-tantalite	9	3	-- r/	-- r/	--	2	1	-- r/	-- r/	--	2	1	-- r/	-- r/	--
Zaire:															
Columbite-tantalite	36	57	29	20	4 7/	9	15	8	5	1	10	16	8	6	1
Pyrochlore e/	780 r/	780 r/	780 r/	780 r/	--	350 r/	350 r/	350 r/	350 r/	--	--	--	--	--	--
Zimbabwe: Columbite-tantalite	35	111	94	94 e/	7 7/	5	17	14	14	1	12	39	33	33	2
Total	36,900 r/	38,100 r/	36,800 r/	29,800 r/	36,500	15,300 r/	15,700 r/	15,300 r/	12,400 r/	15,200	396 r/	477	399 r/	310 r/	325

e/ Estimated. r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes columbium- and tantalum-bearing tin ores and slags. Production of tantalum contained in tin slags was, in thousand kilograms: 1990--343; 1991--244; 1992--160; 1993--132; and 1994--NA according to data from the Tantalum-Niobium International Study Center. Table includes data available through July 5, 1995.

3/ In addition to the countries listed, Bolivia, China, Russia, and Zambia also produce, or are believed to produce, columbium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

4/ Data on gross weight generally have been presented as reported in official sources of the respective countries, divided into concentrates of columbite, tantalite, and pyrochlore where information is available to do so, and reported in groups such as columbite and tantalite where it is not.

5/ Unless otherwise specified, data presented for metal content are U. S. Bureau of Mines estimates based on, in most part, reported gross weight and/or pentoxide content.

6/ Less than 1/2 unit.

7/ Reported figure.

COPPER

By Daniel L. Edelstein

The United States maintained its position as the world's second largest mine producer of copper, accounting for about 19% of world production. Chile, the largest mine producer, accounted for about 24%. Domestic mine production, which had trended upward for most of the previous decade, remained level in 1994 at about 1.8 million tons. However, because of a rise in average copper prices, the value of production rose by more than 20%, to $4.4 billion. About 40 mines operating in 12 States produced reportable quantities of copper; the top 18 mines accounted for more than 98% of production. The five principal mining States, in descending order, Arizona, Utah, New Mexico, Montana, and Michigan, accounted for 98% of production. There were no significant changes in the operating status of domestic copper mines in 1994, though capital expenditures at several mines during the year led to increased production capacity. Capacity was expected to increase slightly in 1995 as several expansions come on stream. U.S. copper companies continued to invest heavily in South America, influenced by favorable geologic settings and a positive international investment climate there. By the third quarter of the year, Phelps Dodge Corp., had commissioned its 115,000-ton-per-year La Candelaria Mine in Chile.

The United States was the largest producer and consumer of refined copper, accounting for 20% and 23%, respectively, of world totals. Domestic consumption of refined copper rose by more than 13.3% during 1994 to record-high levels. This was the third consecutive year of large demand increases, consumption having risen by 6.3% and 8.5%, respectively, in 1992 and 1993.

During the year, 8 primary and 5 secondary smelters, 9 electrolytic and 6 fire refineries, and 15 electrowinning plants operated in the United States. However, at yearend, Southwire Co. announced the immediate closing of its Gaston Recycling Industries secondary smelter and associated electrolytic refinery. Electrowon production of about 490,000 tons, essentially the same as in the previous year, accounted for 27% of domestic mine production. Conversion of old scrap to alloys and refined copper declined by 43,000 tons, but contributed 500,000 tons of copper to the market, a quantity equivalent to about 19% of industrial copper consumption.

Copper was consumed, both as refined copper and as direct melt scrap, at about 35 brass mills, 15 wire rod mills, and 750 foundries, chemical plants, and miscellaneous consumers. Copper and copper alloys found both structural and electrical use in building construction, 42%; electrical products, 22%; industrial machinery and equipment, 13%; transportation equipment, 13%; and consumer and general products, 10 %.

Copper was mined in 55 countries in 1993, of which the top 2, Chile and the United States, accounted for more than 43%, and the top 10 for about 78% of the world total.

Land-based world copper resources at yearend 1993 were estimated at 1.6 billion tons. The world reserve base was estimated at 600 million tons, and world reserves at 300 million tons. The United States has about 15% each of reserves and the reserve base.

The world supply/demand balance for refined copper shifted in 1994. Following 6 years of surplus production and a near tripling of world refined inventories to 1.4 million tons, copper demand exceeded production and global copper inventories declined by 360,000 tons. The shortfall was the result of a slight drop-off in world refined production at a time when estimated world consumption grew by 400,000 tons, or 3.6%. Copper prices, which in November 1993 had fallen to their lowest level in 7 years, rose during 1994 in response to increasing supply tightness. The U.S. producer price averaged $1.41 per pound in December, up from $0.92 in December 1993.

Production

For the second consecutive year, there were relatively few changes in the operating status of domestic mines, smelters, and refineries. Capital investments at a number of facilities led to increased productivity, and set the stage for expanded capacity in 1995. Solvent extraction-electrowon production continued to feel the dilution effects of heavy rains and flooding during 1993 and remained below 1992 levels. Overall mine production capacity rose by about 40,000 tons to 2.08 million tons, principally owing to capacity increases at several of Cyprus Amax Minerals Co.'s mines, and Cobre Mining Co.'s Continental Mine, which was reopened in 1993. Several copper mines were under development and slated for startup in 1995, including Great Lakes Minerals 543-s deposit in Michigan and Arimetco International Inc.'s Zonia and Van Dyke Mines. Phelps Dodge was planning the startup of the Southside Extension at its Morenci Mine for the second half of 1995. Several other mines, including Magma Copper Co.'s Robinson project, were under development and were scheduled for startup in 1996.

While smelter capacity remained unchanged at 1.9 million tons, investments made in 1993 and 1994 led to higher capacity usage and increased primary smelter production. Secondary smelter production declined slightly, and at yearend, Southwire Co. announced the immediate closure of its secondary smelter and the phase-out of the associated electrolytic refinery at its Gaston Copper Recycling Corp., Gaston, SC. High operating costs and the large additional capital investment needed to comply with environmental regulations were cited by the company as the reason for closure. Though refinery capacity declined to 2.5 million tons owing to the closure of the under-utilized Cox Creek Refinery in 1993, production of primary refined copper increased, owing to the pass through of higher smelter output.

Foreign Investments.—Domestic copper companies continued to look toward South American investments to increase capacity and lower average costs. With an improved investment climate, and a far-reaching privatization program begun in 1992, foreign investment in Peruvian mining projects surged. ASARCO Incorporated continued to invest in its majority owned (52.3%) Southern Peru Copper Corp. (SPCC). In May, SPCC, which operated the Toquepala and Cuajone open pits and the Ilo smelter, purchased the government-owned Ilo refinery for $65 million and a commitment to invest an additional $20 million in capital improvements. SPCC was reportedly midway through a $445 million modernization and expansion program, begun in 1992. In November, Magma Copper Co., through its wholly owned subsidiary, Global Magma Ltd., purchased for $245 million a 98.43% interest in Empresa Minera Especial Tintaya S.A., operator of the 50,000-ton-per-year Tintaya Mine in Peru. As part of the purchase, Magma agreed to invest $85 million over 5 years. Plans called for increasing production over 2 years by 27%, and reducing operating costs to $0.55 per pound from the current $0.60. Cyprus Amax acquired approximately 91.5% of the shares of Sociedad Minera Cerro Verde, S.A. in March at a cost of about $31 million and initiated an expansion program to increase annual electrowon production from 18,000 tons to 45,000 metric tons over an 18-month period. Cyprus anticipated expending $375 million over a 5-year period. Cyprus estimated reserves to contain more than 7 billion pounds of copper.

In Chile, Cyprus won the competition for the rights to 51% of El Abra, a world class copper deposit with identified leach reserves of more than 400 million tons of ore, for $330 million. Total development costs of the 115 thousand-ton-per-year oxide leach project, scheduled onstream by mid-1997, were expected to be about $1 billion. Cyprus projected cash operating costs over the first 10 years of operation to average $0.42 per pound of copper. In October, 3 months ahead of schedule, Phelps Dodge Corp. began commercial production at its Candelaria Mine. Phelps Dodge expected to produce about 118,000 tons per year of copper over a 34-year life from identified reserves of more than 350 million tons of ore grading 1.1% copper. In other foreign investments, Freeport-McMoran Copper and Gold Inc. reported being ahead of schedule in expanding milling capacity at its Indonesian operations from the 1994 rate of 72,500 tons of ore per day to 115,000 tons per day by late 1995. Production in 1994 rose to 322,000 tons of recoverable copper, up from 299,000 in 1993, and only 164,000 tons in 1990. Proved and probable reserves were expanded to 1.13 billion tons of ore grading 1.3% copper. Freeport was also expanding its Huelva, Spain, smelter and refinery to 270,000 tons and 215,000 tons, respectively. The expansions were scheduled for completion in early 1996. Freeport also entered into a joint venture with Mitsubishi Materials Corp. (70%) and Fluor Daniel Inc.(10%) to construct a new 200,000-ton smelter/refinery in Indonesia.

Mine and Plant Labor.—Domestic mines employed an average of 13,150 mine, mill and office workers, a decline of about 150 from the previous year. Productivity at domestic copper mines rose to a record high 66 kilograms of copper per worker-hour in 1994, an increase from 64 pounds of copper per worker—hour in 1993. With the exception of 1991, productivity has increased steadily from the 1989 level of 50 kilograms per worker hour. Productivity, which had increased dramatically during the early 1980's, stabilized and even decreased slightly in the late 1980's in the face of higher copper prices. In the 1990's, a renewed round of capital investments and expansions of electrowinning capacity resulted in a renewed improvement in worker productivity.

Costs and Earnings.—While some effects were still being felt from the heavy rains that led to higher costs and lower profits in 1993, higher copper prices and lower operating costs resulted in most domestic mining companies reporting improved profits from copper operations in 1994. Phelps Dodge Mining Co. reported net profits of $326.4 million, an increase of almost $100 million from 1993, but slightly below 1992 profits. Lower operating costs were in part attributed to new production from its Candelaria Mine in Chile. Cyprus Climax Metals Co. reported a near quadrupling of profits from its copper/molybdenum operations to $206 million. The company attributed increased profits to higher metal prices, the company's realized price for copper and molybdenum having risen by $0.15 and $1.15 per pound, respectively, and a 17% improvement in worker productivity. Net operating costs were reportedly reduced from $0.72 to $0.69 per pound of copper. Magma Copper Co. realized a record net income in 1994 of $87.4 million, up from $21.9 million in 1993. Magma attributed the improved financial results to increased sales, an $0.08-per-pound cost reduction in its mined copper, and a rise in the realized price for copper from $0.94 to $0.98 per pound. A price protection program in 1993 and 1994, aimed at assuring a sustained cash flow, resulted in Magma's 1993 realized copper price outperforming Comex by $0.09 per pound, but the 1994 realized price lagging Comex by the same amount. ASARCO Incorporated, reported a rise in net earnings from $15.6 million in 1993 to $64.0 million in 1994, mostly as a result of a $44.9 million contribution from its 52.3% stake in Southern Peru Copper Corp. Production problems at its Ray Mine and El Paso smelter led to a fall-off in production and higher operating costs.

Mines, Smelters, and Refineries.—According to the company's annual report, copper mine production by Asarco fell by about 20,000 tons in 1994, to 260,000 tons, owing to difficult mining conditions at its Ray Mine, in part due to water accumulation from the previous year's heavy rains. In July, production was curtailed at the older, higher-cost sections of the Hayden mill, and a 15-month development plan initiated to restore capacity and increase operating flexibility. Production at the El Paso smelter continued to lag behind 1992 levels as startup troubles with the new CONTOP smelter were resolved. In May, Asarco's redesigned stainless steel reactors were installed and full capacity established. The company began development of a new 4.6 million ton, high-grade (2.07% copper) ore body at the Mission Mine. The ore will be accessed from an incline within the existing pit and was expected to yield 12,700 tons of copper per year over a 5-year period beginning mid-1996.

According to the company annual report, mine production at Phelps Dodge's U.S. operations, including minority owner share, remained unchanged in 1994 at about 584,000 tons. At its Morenci Mine, construction began on the Southside extension project, designed to add 68,000 tons of electrowon production per year, beginning in mid-1995. District-wide exploration in the Morenci area identified almost 700 million tons of leachable material grading 0.28% copper. Additional reserves were also identified at the Chino and Tyrone Mines.

According to the RTZ Corp. PLC annual report, mine production at Kennecott's

Bingham Canyon Mine rose slightly from the record 307,000 tons produced in 1993: higher equipment availability offset a lower average ore grade. Refinery production declined, however, owing to startup problems associated with its refinery modernization. In the first full year of operation, production at the Flambeau Mine exceeded its projected lifetime average of 27,000 tons per year by more than 50% owing to processing of a high-grade material. RTZ reported that its replacement smelter at Magna, UT, was 88% complete at yearend, and was on track for startup in early 1995, 3 months ahead of schedule. At a budgeted cost of $880 million, the new smelter was expected to nearly double output while reducing smelter emissions by 96%. In January, the Environmental Protection Agency (EPA) proposed including large portions of the Bingham Canyon property on the Superfund list. At yearend, final action was still pending on the proposal. To date, Kennecott had spent $115 million on site remediation.

Cyprus Climax Metals Co. reported mine production of 294,000 tons of copper, a nominal increase from the previous year. Capacity increases from fleet modernizations and mill expansion helped to maintain production in light of lower ore grades at its Bagdad and Sierrita Mines and to improve overall employee productivity by 17%. At yearend, the Sierrita mill was operating at a sustained rate of 105,000 tons per day, about 5,000 tons above designed capacity. The Bagdad mill was expanded during 1994 to 77,000 tons per day. In October, Cyprus commissioned a new 120,000-ton-per-year refinery at Miami that would make the company self-sufficient in refining. A study, expected to be completed in mid-1995, was underway to determine the feasibility of a large open-pit and solvent extraction-electrowinning(SX-EW) operation near Casa Grande, AZ.

Arimetco International Inc. reported a record production of 9,000 tons of copper and net profits of $2.7 million in its 1994 annual report. At its Yerington-MacArthur Mine, production rose by 14% to 6,500 tons, owing to expansion of leach pads. At the Johnson Camp Mine, production fell by one-third, to 2,500 metric tons. A shortage of pad space led to curtailment of open pit mining during the first quarter. With completion of additional pad space, mining was resumed. Cash operating costs at Yerington and Johnson were reported to have dropped to $0.50 per pound and $0.65 per pound, respectively, by yearend. Plans called for startup of 60,000-pound-per-day SX-EW operations at both the Van Dyke and Zonia Mines by yearend 1995. Longer term plans called for development of the Yerington sulfides and the Mesaba and Copper Chief ore bodies.

Metall Mining Corp. reported disappointing results from its Copper Range operations. Owing to mining problems, reported production declined by about 4,000 tons to 43,200 tons, and cash operating costs rose from $0.80 to $0.94 per pound of copper. To reduce costs, Metall was investigating the feasibility of leaching copper from pillars in abandoned sections of the mine. As part of a consent decree to settle outstanding litigation regarding smelter noncompliance with emissions standards, Metall agreed to close its smelter, beginning in February 1995. Concentrates were to be processed in Canada, with anode returned to Copper Range for refining. A decision to build a new compliant smelter was pending the outcome of its leach tests. However, at mid-1995, Metall announced the immediate suspension of mining and milling at Copper Range, though work on the leaching feasibility continued.

Trade

In response to growing demand coincident with stagnant production, U.S. import dependance for refined copper rose to the highest level in 7 years. Imports of refined copper rose to near record levels, while exports, principally to Asian countries, declined. Imports of copper and brass semifabricates rose by almost 17,000 tons, to 82,000 tons, while exports declined by about 4,000 tons, to 455,000 tons. Trade in copper concentrates increased, though net imports remained essentially unchanged at 180,000 tons. Concentrate exports were increased by one major producer as environmental constraints curtailed its smelter output. Other smelters increased purchases to maintain smelter efficiency in light of mine production shortfalls.

In April, as an amendment to the Uruguay Round of the General Agreement on Tariffs and Trade (GATT), completed in December 1993, Japan announced that it would phase down its copper duty over a 5-year period from a flat 15,000 yen per ton, about 8% ad valorem at prevailing prices, to 3% ad valorem.

Prices and Stocks

The global supply/demand balance for refined copper shifted dramatically in 1994 from surplus to deficit. World inventories declined precipitously throughout 1994, extending a trend begun in November 1993. Before that, inventories had been growing since early 1990, except for a brief dip in 1992. In the United States, however, strong demand in 1993 had precipitated a decline in stocks a few months earlier; domestic inventories had peaked in May 1993 and fallen by 25% by yearend.

Global copper prices, which in November 1993 were at the lowest level in over 6 years, rose slightly during the first quarter of 1994. The U.S. producer price averaged $0.91 per pound during the first 4 months of 1994, up from the low in November 1993 of $0.86. In May, in response to a continued drawdown of domestic and world inventories, prices began to move sharply upward: the U.S. producer price averaged $1.41 per pound in December, the highest level in 5 years. Domestic inventories fell to a minimum in October of only 95,000 tons, or, at the prevailing rate of consumption, less than 2 weeks of supply. Tightness in copper supply was further evidenced by the backwardation, forward contracts selling at a discount to spot purchases, that developed in Comex prices. While forward contracts traded at a slight premium early in the year, by May, forward contracts were consistently trading at a discount. The backwardation widened with rising prices, and in December, the discount for 3-month forward contracts averaged $0.24 per pound.

In September, the U.S. Defense National Stockpile Center completed the sell-off of more than 8,000 tons of brass slabs being stored in depots in Nevada and Indiana. Inventories of refined copper had been liquidated during 1993.

Consumption

Domestic consumption of refined copper rose 13% during 1994 to a record-high level. This followed on the heels of above average growth in 1992 and 1993, demand having risen by 6.3% and 8.5%, respectively, during these years. Demand showed signs of slowing at yearend, with consumption for December falling below that for the comparable month in 1993. The growth in demand was fueled by strong economic activity in the major end use markets: housing starts and building permits rose by 12.9% and 13.7%, respectively, and automobile sales and production rose by 8.6% and 11.8%, respectively. According to data compiled by the Copper Development Association Inc. (CDA) on copper and copper alloy shipments to the U.S. market, building construction demand rose 8% and accounted for 42% of shipments; electric and electrical products demand rose about 2% and accounted for 22% of shipments; industrial machinery demand rose 6% and accounted for 13% of shipments; transportation equipment demand rose 15% and accounted for 13% of shipments; and consumer and general product demand rose 24% and accounted for 10% of shipments. Total shipments rose about 9%, to 3.36 million tons. According to estimates by the U.S. Bureau of Mines, electrical applications in all industry segments accounted for 78% of refined copper consumption.

The domestic scrap market was relatively weak in 1994, and did not reflect the strong growth in copper demand. The quantity of copper recovered from old scrap was lower in 1994 owing to a fall-off in secondary refined production. Low copper prices during the first half of the year and the small difference between the price of refined copper and scrap copper served to discourage the conversion to refined copper. At brass mills, where industry accounts indicated that mills were running at capacity throughout much of the year, consumption of scrap rose by 16%. However, brass mills typically consume large quantities of new scrap returned from customers. With industry consuming increased amounts of both domestic and foreign brass mill products, new scrap availability increased. While domestic consumption of scrap at refineries was weak, scrap dealers reported a strong market, owing to a vigorous demand for copper scrap in Asian markets. U.S. exports of copper and copper-alloy scrap through November rose to about 360,000 tons, up from 262,000 in 1993. The strong export market served to bolster scrap prices and led to the narrower processing margins that discouraged domestic scrap consumption.

World Review

The global supply/demand balance shifted from one of surplus in 1993 to a significant deficit in 1994. According to data compiled by the International Copper Study Group, world demand for refined copper increased by 400,000 tons and world inventories declined by more than 350,000 tons. The United States, where consumption grew by more than 13%, accounted for about 75% of the net growth in global demand. Demand in Europe, which declined in 1993, grew by about 2%, while demand in Asia and the Middle East was stagnant. Production of refined copper, on the other hand, declined by more than 300,000 tons, principally owing to lower production in China, Japan, Kazakhstan, Russia, and Zambia. Increased competition for concentrates and appreciation of the yen led to a 10% reduction in Japanese production.

World mine production fell slightly during 1994 despite a net gain in world capacity of about 100,000 tons. In Canada, production fell by more than 100,000 tons owing to mine closures in British Columbia in late 1993 that were attributed to high costs and low copper prices. However, by yearend 1994, mining had been resumed at Princeton Mining's Similco Mine and at Gibraltar Mines Ltd.'s Mcleese Lake Mine. A labor dispute that curtailed production at Westmin Resources Ltd.'s Myra Falls copper-zinc mine was settled in August. In the Philippines, high costs and typhoon damage reduced production at Atlas Consolidated Mining and Development Corp.'s operations. Erosion of infrastructure led to a continued decline in Russian production, and in Zambia technical difficulties led to a decline in production. Zambia Consolidated Copper Mines Ltd. announced a company-wide cost-cutting program, and at yearend the government was considering reducing its 60% ownership of the company. Political turmoil continued to plague Zairian production.

Notable production increases occurred in Chile and Indonesia. In Chile, Phelps Dodge's Candelaria Mine began production during the third quarter, and at midyear production began from the Quebrada Teniente deposit at Codelco's El Teniente Division. Other new capacity included the commissioning of an 80,000-ton-per year Ammonia leach plant at Escondida, and startup of the Quebrada Blanca, Cerro Colorado and Ivan SX-EW operations. In Indonesia, mill expansion led to increased production from the Grasberg Mine.

With an increased share of mine production coming from SX-EW, and a growth in world smelter capacity of more than 400,000 tons over a 2-year period, a shortage of copper concentrates developed in 1994. Smelter capacity utilization was low, and spot treatment and refining charges were at very low levels during the year. According to CRU International Ltd., spot treatment and refining charges averaged only about $0.13 per pound of copper, down from about $0.22 in 1993. Treatment and refining charges negotiated under long-term contracts, however, were reported to be substantially higher, at about $0.25 per pound.

Outlook

U.S. mine production, which has been relatively stable over the past 2 years, is expected to increase, beginning in the second half of 1995, with start-up of Morenci's Southside extension and Great Lakes Minerals' 543-s deposit. Small increases are expected from Asarco's Ray Mine and the new underground mine at Mission, and Arimetco's Yerington and Van Dyke Mines. In early 1995, Arimetco announced plans to begin dewatering of the Yerington pit. Start-up of Magma's Robinson project in 1996 is expected to further add to capacity and overshadow reductions in SX-EW production at its San Manuel open pit. Total domestic mine production is projected to reach 1.9 million tons in 1996.

Domestic refinery production, which declined slightly in 1994, is expected to increase in the second half of 1995 with commissioning of the new Kennecott smelter, which will feed the refurbished refinery, and increased SX-EW production from Phelps Dodge. Production will increase significantly in 1996 as these facilities come up to capacity. There will be an off-setting loss from reduced SX-EW production at San Manuel, and secondary production will decline with the closing of Southwire's Gaston smelter/refinery. In mid-1995, Metall Mining announced plans to stop mining/refining at Copper Range by yearend. By 1996, overall refinery production is expected to increase by more than 150,000 tons from the 1994 level.

Domestic copper consumption was at a record level in 1994, having risen by more than 30% from the depressed 1991 level. While consumption in early 1995 remained strong, it showed signs of weakening in later months, and leading economic indicators showed a market softening. Although the dramatic growth in copper consumption experienced over the past 3 years is not expected to continue, consumption is projected to remain near 1994 levels through 1995, and to rise at a slower rate in 1996.

World mine capacity is expected to grow rapidly in the next several years. According to data compiled by the International Copper Study Group (ICSG), announced expansions could increase mine capacity by more than 1.8 million tons by 1998, and 3 million tons by the year 2000. Much of the slated increases are in Chile, where capacity could rise from the current 2.4 million tons per year to 3.4 million tons in 1997, and 4.2 million tons in 2000. Major increases are also anticipated from mines in Australia, Indonesia, Peru, and the Philippines. Zaire is seeking funds to help restore an estimated 100,000 tons of capacity. With new smelter projects under consideration in more than 12 countries, smelter capacity could rise by the year 2000 by more than 2 million tons. Major new or expanded smelter production planned for 1995 includes the Chagres smelter in Chile, the Garfield smelter in the United States, and several smaller smelters in China, India, the Philippines, and Mexico. Increases in refinery capacity will mostly be from electrowinning.

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TABLE 1
SALIENT COPPER STATISTICS 1/

(Metric tons unless otherwise specified)

		1990	1991	1992	1993	1994
United States:						
Mine production:						
Ore concentrated 2/	thousand metric tons	241,000 r/	261,000 r/	263,000 r/	262,000 r/	271,000
Average yield of copper 2/	percent	0.49 r/	0.45 r/	0.48 r/	0.49 r/	0.47
Recoverable copper:						
Arizona		979,000	1,020,000	1,150,000	1,160,000	1,120,000
Michigan, Montana, Utah		322,000	337,000	385,000	387,000	397,000
New Mexico		263,000	253,000	211,000	224,000	234,000
Other States		23,900	17,000	16,000	31,100	55,700
Total recoverable		1,590,000	1,630,000	1,760,000	1,800,000	1,810,000
Total value	millions	$4,310	$3,930	$4,180	$3,640	$4,430
Smelter production: 3/						
From domestic and foreign ores		1,160,000	1,120,000	1,180,000	1,270,000	1,310,000
From scrap (new and old)		305,000	364,000	394,000	415,000	397,000
Total smelter		1,460,000	1,490,000	1,570,000	1,680,000	1,710,000
Byproduct sulfuric acid	thousand metric tons	1,110 r/	1,100 r/	1,090 r/	1,190 r/	1,180
Refinery production:						
Primary materials:						
Electrolytic from domestic ores		1,110,000	1,060,000	1,110,000	1,210,000	1,280,000
Electrolytic from foreign materials		74,600	76,900	96,100	88,600	63,500
Electrowon		393,000	441,000	502,000	491,000	493,000
Total primary		1,580,000	1,580,000	1,710,000	1,790,000	1,840,000
Secondary materials (scrap):						
Electrolytic		328,000	318,000	331,000	337,000	269,000
Fire refined		113,000	99,600	102,000	123,000	122,000
Total secondary		441,000	418,000	433,000 r/	460,000	392,000
Total refined		2,020,000	2,000,000	2,140,000	2,250,000	2,230,000
Secondary copper produced:						
Recovered from new scrap		774,000	682,000	723,000	748,000	827,000
Recovered from old scrap		537,000	518,000	555,000	543,000	500,000
Total copper from scrap		1,310,000	1,200,000	1,280,000	1,290,000	1,330,000
Copper sulfate:						
Production		34,300	40,200	46,800	46,400	48,400
Stocks, Dec. 31		1,410	2,380	2,860	2,990	2,510
Exports:						
Refined		211,000	263,000	177,000	217,000	157,000
Unmanufactured 4/		780,000	806,000	676,000	685,000	752,000
Imports:						
Refined		262,000	289,000	289,000	343,000	470,000
Unmanufactured 4/		512,000	512,000	593,000	637,000	763,000
Copper stocks, Dec. 31:						
Blister and in-process material		119,000	135,000	166,000	146,000	171,000
Refined copper:						
Refineries		26,000	38,300	35,500	33,400	42,500
Wire rod mills		24,300	29,600	37,000	34,700	39,800
Brass mills		9,780	10,700	12,500	14,100 r/	8,530
Other industry		23,200	22,800	23,800	3,650 r/	4,100
New York Commodity Exchange (COMEX)		18,000	30,600	96,000	67,200	24,200
Total refined		101,000	132,000	205,000	153,000	119,000
Consumption:						
Refined copper, reported		2,150,000	2,050,000	2,180,000	2,360,000	2,680,000
Apparent consumption, primary refined and old scrap		2,170,000	2,090,000	2,300,000	2,510,000 r/	2,680,000
Price:						
Producer, weighted average	cents per pound	123.16	109.33	107.42	91.56	111.05
COMEX, first position	do.	119.09	104.88	102.72	85.28	107.05
London Metal Exchange (LME), Grade A cash	do.	121.02	106.21	103.72	86.76	104.64
World production:						
Mine	thousand metric tons	8,950 r/	9,140 r/	9,500 r/	9,480 r/	9,430
Smelter	do.	9,680 r/	9,610 r/	9,660 r/	9,560 r/	9,750
Refinery	do.	10,800	10,600	11,100 r/	11,400	11,100

r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices; may not add to totals shown.

2/ Data series revised to reflect only ore concentrated. Yield calculations include precipitates.

3/ Includes primary copper produced from foreign ores, matte, etc., to avoid disclosing company proprietary data.

4/ Includes copper content of alloy scrap. Copper content of alloy scrap imported and exported in 1990 was estimated from gross weight.

TABLE 2
LEADING COPPER PRODUCING MINES IN THE UNITED STATES IN 1994, IN ORDER OF OUTPUT 1/

Rank	Mine	County and State	Operator	Source of copper	Capacity (thousand metric tons)
1	Morenci	Greenlee, AZ	Phelps Dodge Corp.	Copper-molybdenum ore, concentrated and leached.	400
2	Bingham Canyon	Salt Lake, UT	Kennecott, Utah Copper Corp.	do.	310
3	San Manuel	Pinal, AZ	Magma Copper Co.	do.	170
4	Chino	Grant, NM	Phelps Dodge Corp.	do.	160
5	Ray	Pinal, AZ	ASARCO Incorporated	Copper ore, concentrated and leached.	150
6	Bagdad	Yavapai, AZ	Cyprus Minerals Co.	Copper-molybdenum ore, concentrated and leached.	130
7	Sierrita	Pima, AZ	do.	do.	135
8	Pinto Valley	Gila, AZ	Magma Copper Co.	do.	90
9	Mission Complex	Pima, AZ	ASARCO Incorporated	Copper ore, concentrated.	90
10	Tyrone	Grant, NM	Phelps Dodge Corp. and Burro Chief Copper Co.	Copper ore, concentrated and leached.	70
11	Inspiration	Gila, AZ	Cyprus Minerals Co.	Copper ore, leached.	60
12	Continental	Silver Bow, MT	Montana Resources Inc.	Copper-molybdenum ore, concentrated.	50
13	White Pine	Ontonagon, MI	Copper Range Co.	Copper ore, concentrated.	60
14	Flambeau	Rusk, WI	Kennecott Corp.	do.	40
15	San Xavier	Pima, AZ	ASARCO Incorporated	do.	35
16	Continental	Grant, NM	Cobre Mining Co.	do.	20
17	Superior (Magma)	Pinal, AZ	Magma Copper Co.	do.	20
18	Miami	Gila, AZ	do.	Copper ore, leached.	12

1/ The mines in this list accounted for 98% of the U.S. mine production in 1994.

TABLE 3
MINE PRODUCTION OF COPPER-BEARING ORES AND RECOVERABLE COPPER CONTENT OF ORES PRODUCED IN THE UNITED STATES, BY SOURCE AND TREATMENT PROCESS 1/

(Metric tons)

Source and treatment process	1993 Gross weight	1993 Recoverable copper	1994 Gross weight	1994 Recoverable copper
Mined copper ore:				
Concentrated	262,000,000	1,270,000	271,000,000 2/	1,240,000
Leached 3/	NA	491,000	NA	493,000
Total	NA	1,760,000	NA	1,740,000
Copper precipitates shipped; leached from tailings, dump, and in-place material	25,900	19,000	30,200	26,400
Other copper-bearing ores 4/	5,870,000	25,900	6,000,000	49,300
Grand total	XX	1,800,000	XX	1,810,000

NA Not available. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ In 1994, 584,189 ounces of gold, and 12,366,989 ounces of silver, were recovered from concentrated ore. The average value of gold and silver per metric ton of ore concentrated was $1.08.

3/ Includes electrowon from concentrates roast-leached in 1993. Not all producers are able to distinguish leach ore from waste rock. Values previously published for the gross weight of leach ore were significantly under valued because they excluded undifferentiated leach/waste material.

4/ Includes gold ore, gold-silver ore, lead ore, lead-copper ore, lead-zinc ore, molybdenum ore, silver ore, tungsten ore, zinc ore, fluorspar, flux ores, clean up, ore shipped directly to smelters, and tailings.

TABLE 4
CONSUMPTION OF COPPER AND BRASS MATERIALS IN THE UNITED STATES, BY ITEM 1/

(Metric tons)

Item	Brass mills	Wire rod mills	Foundries, chemical plants, miscellaneous users	Secondary smelters-refiners 2/	Total
1993:					
Copper scrap	744,000 r/ 3/	W	60,700	892,000 r/	1,700,000
Refined copper 4/	503,000 r/	1,820,000	40,800 5/	(6/)	2,360,000
Hardeners and master alloys	875	--	3,010	--	3,880 r/
Brass ingots	--	--	113,000	--	113,000
Slab zinc	85,800	--	19,000	3,390	108,000
Miscellaneous	--	--	--	41	41
1994:					
Copper scrap	862,000 3/	W	67,100	779,000	1,710,000
Refined copper 4/	568,000	2,060,000	47,100 5/	(6/)	2,680,000
Hardeners and master alloys	841	--	2,650	--	3,490
Brass ingots	--	--	120,000	--	120,000
Slab zinc	89,200	--	12,900	4,200	106,000
Miscellaneous	--	--	--	15	15

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Brass mills."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes ingot makers.

3/ Includes consumption of copper scrap at wire rod mills to avoid disclosing company proprietary data.

4/ Detailed information on consumption of refined copper can be found in table 5.

5/ Includes consumption of refined copper at secondary smelters-refiners to avoid disclosing company proprietary data.

6/ Withheld to avoid disclosing company proprietary data; included in "Foundries, chemicals plants, miscellaneous users."

TABLE 5
CONSUMPTION OF REFINED COPPER SHAPES IN THE UNITED STATES, BY CLASS OF CONSUMER 1/

(Metric tons)

Class of consumer	Cathodes	Ingots and ingot bars	Cakes and slabs	Wirebar, billets and other	Total
1993:					
Wire rod mills	1,820,000	--	--	--	1,820,000
Brass mills	313,000 r/	32,600	55,500 r/	102,000	503,000 r/
Chemical plants	--	--	--	865 r/	865 r/
Ingotmakers	W	W	W	2,170	2,170
Foundries	1,580	5,090	W	3,530	10,200
Miscellaneous 2/	W	W	W	27,600	27,600
Total	2,130,000	37,700	55,500 r/	136,000	2,360,000
1994:					
Wire rod mills	2,060,000	--	--	--	2,060,000
Brass mills	339,000	32,700	73,200	124,000	568,000
Chemical plants	--	--	--	1,130	1,130
Ingotmakers	W	W	W	4,490	4,490
Foundries	2,060	4,570	W	4,430	11,100
Miscellaneous 2/	W	W	W	30,400	30,400
Total	2,410,000	37,300	73,200	164,000	2,680,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Wirebar, billets and other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and other manufacturers.

TABLE 6

U.S. EXPORTS OF UNMANUFACTURED COPPER (COPPER CONTENT), BY COUNTRY 1/

Country	Ore and concentrate		Matte, ash and precipitates		Refined		Unalloyed copper scrap		Blister and anodes		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993	227,000	$264,000	13,100	$22,400	217,000	$416,000	110,000	$126,000	11,400	$25,700	578,000	$854,000
1994:												
Argentina	--	--	56	596	--	--	--	--	--	--	56	596
Australia	1	3	129	775	17	69	29	66	(2/)	4	177	917
Belgium	36	36	2,140	8,280	8	12	1,130	1,330	--	--	3,310	9,660
Canada	142,000	188,000	20,400	16,000	18,900	44,600	73,700	98,700	10,800	27,500	266,000	374,000
China	--	--	17	40	3,790	7,570	19,100	21,900	13	20	22,900	29,500
El Salvador	--	--	--	--	1,270	2,870	3	24	2	16	1,280	2,910
Germany	9	44	18	159	413	1,130	157	167	2	18	599	1,520
Honduras	2	4	2	12	662	1,640	--	--	--	--	665	1,660
Hong Kong	4	5	80	123	110	206	13,700	12,900	3	14	13,900	13,200
India	--	--	482	319	61	33	1,830	1,700	33	52	2,400	2,100
Italy	--	--	--	--	2,570	5,270	445	818	159	321	3,180	6,410
Japan	85,900	97,900	1,140	2,510	45,800	103,000	19,700	39,100	449	607	153,000	243,000
Korea, Republic of	11,600	18,100	--	--	2,190	4,160	8,680	16,400	26	51	22,500	38,700
Mexico	87	94	35	52	5,930	12,300	177	194	147	230	6,380	12,800
Netherlands	--	--	--	--	850	1,550	162	280	3	12	1,010	1,840
Philippines	20,200	23,400	--	--	--	--	23	6	8	34	20,300	23,400
Singapore	--	--	--	--	1,030	2,120	451	580	--	--	1,480	2,700
Taiwan	3	3	353	836	56,400	133,000	1,420	2,090	113	208	58,300	136,000
Thailand	--	--	--	--	14,600	35,600	40	50	15	51	14,600	35,700
United Kingdom	267	512	5	14	432	660	41	61	10	14	756	1,260
Other	34	41	228	129	1,530	3,590	946	1,070	25	50	2,770	4,880
Total	261,000	328,000	25,100	29,800	157,000	359,000	142,000	197,000	11,900	29,200	596,000	943,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 7
U.S EXPORTS OF COPPER SEMIMANUFACTURES, BY COUNTRY 1/

Country	Pipes and tubing		Plates, sheets, foil, and bars		Bare wire, including wire rod 2/		Wire and cable, stranded		Copper sulfate	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993	18,800	$68,800	26,600	$96,100	42,600	$159,000	11,800	$58,900	334	$771
1994:										
Australia	178	771	76	416	48	246	54	254	9	29
Canada	8,620	28,800	17,100	54,000	14,000	39,600	4,170	14,000	829	1,290
Chile	107	332	2	27	45	164	43	278	--	--
China	193	1,030	693	1,730	183	350	159	258	--	--
Colombia	176	439	14	54	13	70	58	485	--	--
Costa Rica	112	372	1,160	4,300	189	587	49	167	--	--
Dominican Republic	36	120	584	1,540	756	2,780	354	1,130	--	--
El Salvador	11	51	809	2,220	6	13	181	821	--	--
France	68	363	31	116	5	70	66	881	--	--
Germany	8	71	102	778	39	613	154	2,640	--	--
Guatemala	135	229	9	51	3	8	88	363	--	--
Hong Kong	12	71	1,520	9,490	264	1,620	124	635	--	--
Iran	99	539	--	--	--	--	5	418	--	--
Ireland	2	149	(3/)	14	42	242	102	587	--	--
Israel	20	68	1	22	25	264	78	603	13	36
Jamaica	12	48	240	658	33	94	108	483	--	--
Japan	44	339	500	3,850	2,870	6,200	96	842	--	--
Korea, Republic of	463	529	398	3,220	322	615	97	1,260	5	60
Mexico	4,870	15,800	4,090	14,100	24,300	81,900	2,700	16,200	21	67
Netherlands	363	1,390	3	68	9	120	11	255	--	--
New Zealand	165	739	16	135	(3/)	8	7	37	(3/)	4
Norway	--	--	643	1,990	7	33	7	76	--	--
Philippines	19	58	41	171	27	88	155	1,080	(3/)	6
Russia	2	4	--	--	--	--	235	1,250	--	--
Saudi Arabia	387	1,260	1	17	88	636	291	477	--	--
Singapore	23	98	164	1,020	50	558	34	529	6	13
Spain	339	886	1	16	6	40	2	56	--	--
Taiwan	467	2,900	490	3,750	614	1,520	162	1,120	41	85
Thailand	449	1,410	67	232	4	31	35	803	--	--
Trinidad and Tobago	1	6	24	93	771	2,070	42	188	--	--
United Arab Emirates	440	1,450	--	--	7	41	3	68	--	--
United Kingdom	288	1,750	149	1,440	241	1,150	221	2,090	4	11
Venezuela	222	845	97	334	29	149	342	1,940	--	--
Other	960	3,490	254	1,760	579	3,330	776	4,870	69	84
Total	19,300	66,400	29,300	108,000	45,600	145,000	11,000	57,200	997	1,680

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Total exports of wire rod for 1993 were 3,270 tons valued at $8,450,000 and 1994 were 7,230 tons valued at $15,400,000.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 8

U.S. IMPORTS FOR CONSUMPTION OF UNMANUFACTURED COPPER (COPPER CONTENT), BY COUNTRY 1/

Country	Ore and concentrate		Matte, ash and precipitates		Blister and anode		Refined		Unalloyed scrap		Total	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
1993	37,000	$46,200	2,300	$2,430	97,600	$201,000	343,000	$669,000	45,800	$74,100	526,000	$993,000
1994:												
Brazil	--	--	--	--	--	--	22,600	51,800	--	--	22,600	51,800
Bulgaria	--	--	--	--	1,180	2,290	21	39	--	--	1,210	2,330
Canada	19,900	42,500	1,170	802	55	108	270,000	616,000	19,500	39,100	311,000	699,000
Chile	49,700	60,100	--	--	41,600	81,600	82,700	178,000	86	202	174,000	319,000
Costa Rica	--	--	--	--	--	--	--	--	553	407	553	407
Germany	--	--	--	--	(3/)	2	26,700	69,000	239	384	26,900	69,400
Indonesia	7,960	21,300	--	--	--	--	--	--	--	--	7,960	21,300
Japan	--	--	--	--	(3/)	13	6,470	14,800	--	--	6,480	14,900
Mexico	4,290	6,810	6	565	14,800	26,700	24,400	55,600	17,500	28,900	61,000	119,000
Namibia	--	--	--	--	2,150	5,080	--	--	--	--	2,150	5,080
Panama	--	--	--	--	--	--	--	--	661	1,190	661	1,190
Peru	--	--	--	--	13,300	25,100	14,800	31,800	36	26	28,200	57,000
Poland	--	--	--	--	--	--	8,900	19,800	--	--	8,900	19,800
Russia	--	--	--	--	--	--	12,000	32,100	--	--	12,000	32,100
Turkey	--	--	--	--	4,000	10,300	--	--	--	--	4,000	10,300
United Kingdom	--	--	--	--	(3/)	2	(3/)	4	460	354	460	360
Venezuela	--	--	--	--	--	--	--	--	3,160	2,210	3,160	2,210
Other	--	--	4	10	189	357	1,450	3,470	2,500	2,420	4,140	6,250
Total	81,900	131,000	1,180	1,380	77,300	152,000	470,000	1,070,000	44,700	75,100	675,000	1,430,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ C.i.f. value at U.S. port.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF COPPER SEMIMANUFACTURES, BY COUNTRY 1/

Country	Pipes and tubing		Plates, sheets, foil, and bars		Bare wire, including wire rod		Wire and cable, stranded		Copper sulfate	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
1993	63	$635	50,000	$200,000	19,700	$53,900	604	$3,760	9,430	$8,690
1994:										
Belgium	1	9	77	625	14	80	1	8	--	--
Canada	6	47	14,500	47,800	25,200	61,800	206	594	3,610	2,730
Chile	20	74	1,410	3,970	183	466	--	--	423	343
China	--	--	147	796	842	3,150	--	--	245	164
Finland	--	--	3,860	14,300	315	1,390	(3/)	21	--	--
France	20	80	347	1,120	178	1,180	20	268	102	84
Germany	3	46	6,080	21,200	349	2,190	96	608	513	608
Israel	1	2	36	95	678	4,030	313	2,070	804	651
Italy	--	--	26	72	30	206	108	1,060	--	--
Japan	3	266	7,820	41,400	223	2,600	28	1,060	6	58
Luxembourg	--	--	570	5,140	--	--	--	--	--	--
Macedonia	--	--	253	578	--	--	--	--	--	--
Malaysia	--	--	869	5,710	--	--	--	--	--	--
Mexico	4	43	1,340	4,430	657	2,020	261	589	4,550	4,640
Netherlands	--	--	87	361	74	373	--	--	402	321
Peru	--	--	68	134	--	--	--	--	340	253
Poland	--	--	404	1,020	--	--	--	--	20	15
Russia	--	--	2	12	--	--	--	--	162	122
South Africa, Republic of	--	--	--	--	--	--	--	--	940	613
Sweden	--	--	12,100	43,200	4	6	(3/)	2	--	--
Taiwan	(3/)	4	31	300	43	283	20	127	181	118
Turkey	--	--	--	--	481	1,850	64	254	--	--
United Kingdom	5	68	241	1,410	73	725	4	80	--	--
Venezuela	13	36	10	18	--	--	269	865	--	--
Other	17	42	621	2,030	65	558	31	151	96	116
Total	94	718	50,800	196,000	29,400	82,900	1,420	7,750	12,400	10,800

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ C.i.f. value at U.S. port.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
COPPER: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Albania	11,500	6,100	3,900	3,900 e/	3,900
Argentina	400	400	300	300 r/ e/	300
Armenia	XX	XX	2,000	500 e/	500
Australia	327,000	320,000	378,000	402,000 r/	416,000 3/
Bolivia	200	100 r/	101 r/	94 r/	79 3/
Botswana 4/	20,600	20,600	20,400	20,100 r/	22,800 3/
Brazil	36,400	37,900	39,800 r/	43,400 r/	45,000
Bulgaria	32,900	47,200	47,400 r/	60,400 r/	60,000
Burma	4,630 r/	4,590 r/	3,730 r/	3,580 r/	5,800
Canada:					
By concentration or cementation	790,000	808,000	766,000	731,000	623,000
Leaching (electrowon)	3,700	3,300	3,100	2,700	3,000
Chile 5/	1,590,000	1,810,000	1,930,000	2,060,000 r/	2,220,000 3/
China e/	285,000	304,000	334,000	345,000 r/	350,000
Colombia	300	3,600	3,900	4,000 e/	4,000
Cuba e/	2,000 r/	2,000 r/	1,500 r/	1,500 r/	1,400
Cyprus	-- r/	-- r/	-- r/	-- r/	--
Czechoslovakia 6/ 7/ 8/	3,300	2,600	2,500 e/	XX	XX
Ecuador e/	100	100	100	100	100
Finland	12,600	11,700	9,270 r/	11,100 r/	8,740 3/
France	300 e/	300 e/	100	72 r/	--
Georgia e/	XX	XX	6,000	5,000	3,000
Germany:					
Eastern states	3,600	XX	XX	XX	XX
Western states	-- r/	XX	XX	XX	XX
Total	3,600	--	--	--	--
Honduras	1,400	1,000 e/	1,600	1,000 r/ e/	1,000
India e/	58,200	55,400 3/	55,000	58,200	50,700
Indonesia 6/	164,000	212,000	281,000	299,000	322,000 3/
Iran	65,800 r/	84,300 r/	105,000	86,600	120,000
Japan	12,900	12,400	12,100	10,300 r/	6,040 3/
Kazakhstan e/	XX	XX	250,000 r/	250,000 r/	202,000 3/
Korea, North e/	15,000	15,000	16,000	16,000	16,000
Korea, Republic of	53 r/	5	4	5	5
Macedonia e/	XX	XX	7,200	7,000	7,000
Malaysia	24,300	25,600	28,600	25,200	25,300 3/
Mexico:					
By concentration or cementation	267,000 r/	260,000 r/	263,000 r/	274,000 r/	260,000 3/
Leaching (electrowon)	26,900	32,100	27,900 r/	30,000 r/	35,000 3/
Mongolia	124,000	90,100	105,000	96,900 r/	99,600 3/
Morocco	16,400	15,800	14,300	14,000 e/	13,600
Mozambique e/	28	--	--	--	-- 3/
Namibia	27,800 r/	31,700 r/	31,300 r/	29,500 r/	28,400 3/
Nepal	3	4	2	2	2
Norway	19,700	17,400	12,700	8,700 r/	7,410 3/
Oman	14,000	14,000	13,600	12,000 e/	6,500
Papua New Guinea	170,000	204,000 r/	193,000	204,000 r/	206,000 3/
Peru: 9/					
By concentration or cementation	323,000 r/	382,000	369,000	375,000 r/	380,000
Leaching (electrowon)	16,300	17,900	19,000	18,300 r/	19,000
Philippines	182,000	148,000	124,000	136,000	110,000 3/
Poland	330,000 r/	320,000 r/	332,000 r/	383,000 r/	328,000
Portugal 9/	163,000	165,000	148,000	150,000 r/ e/	139,000
Romania 6/	32,000	27,200	25,000	27,000 e/	27,000
Russia	XX	XX	699,000 r/	584,000 r/	573,000 3/
Saudi Arabia e/	900	900	900	900	900
Serbia and Montenegro	XX	XX	90,000	85,000 e/	85,000
Slovakia 8/	XX	XX	XX	500 e/	500
South Africa, Republic of 6/	179,000	185,000	176,000	166,000 r/	165,000 3/
Spain	10,900	8,320 r/	9,430 r/	3,520 r/	4,890
Sweden	74,300	81,700 r/	89,100 r/	88,900 r/	79,400 3/
Turkey 10/	33,500 r/	33,100 r/ e/	26,500 r/ e/	22,900 r/	31,000

See footnotes at end of table.

TABLE 10--Continued

COPPER: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
U.S.S.R. e/ 11/	950,000	900,000	XX	XX	XX
United Kingdom	1,000	300	--	--	--
United States: 6/					
By concentration or cementation	1,190,000	1,190,000	1,260,000	1,310,000	1,320,000 3/
Leaching (electrowon) 12/	394,000	441,000	502,000	491,000	488,000 3/
Uzbekistan e/	XX	XX	75,000 r/	70,000 r/	70,000
Yugoslavia 13/ 14/	140,000	138,000 e/	XX	XX	XX
Zaire: 15/					
By concentration or cementation	127,000 r/	57,500 r/	37,000 r/	6,400 r/	7,200
Leaching (electrowon)	229,000	180,000 e/	107,000 r/	40,000 r/ e/	32,800
Zambia: 16/					
By concentration or cementation (smelted)	316,000 r/	281,000 r/	322,000 r/	285,000 r/	273,000 3/
Leaching (electrowon)	105,000	110,000	108,000	111,000 r/	112,000 3/
Zimbabwe e/ 6/	14,700 3/	14,400	10,100	9,000	9,350
Total	8,950,000 r/	9,140,000 r/	9,500,000 r/	9,480,000 r/	9,430,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Data represent copper content by analysis of concentrates produced except where otherwise noted. Table includes data available through July 17, 1995.

3/ Reported figure.

4/ Copper content of pelletized nickel-copper matte produced in smelter.

5/ Reported by Comision Chilena del Cobre (COCHILCO). Includes recoverable copper content of nonduplicative mine and metal products produced from domestic ores and concentrates, and leach production for electrowinning. Mine production data reported by Servicio Nacional de Geologia y Mineria (SERNAGEOMIN) were as follows, in thousand metric tons: 1990--1,620; 1991--1,860; 1992--1,970; 1993--2,090 (revised); and 1994--2,250 (estimated).

6/ Recoverable content.

7/ Dissolved Dec. 31, 1992.

8/ Production in Czechoslavakia for 1990 came from the Czech Republic and Slovakia, all production from 1991-94 came from Slovakia.

9/ Recoverable copper content by analysis of concentrates for export plus nonduplicative total of copper content of all metal and metal products produced indigenously from domestic ores and concentrates; includes leach production for electrowinning in Peru and Portugal.

10/ Excludes copper content of pyrite.

11/ Dissolved in Dec. 1991.

12/ Includes electrowon from concentrates roast-leached.

13/ Dissolved in Apr. 1992.

14/ Copper content by analysis of ore mined.

15/ Recoverable content of blister, black copper, and Sodimiza concentrate.

16/ Data are for fiscal years beginning Apr. 1 of year stated. Zambian-mined copper reported recovered during smelting and electrowinning.

TABLE 11
COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Albania, primary	11,800 r/	4,800	2,300 r/	2,300 r/	1,500
Australia:					
Primary	192,000	195,000	304,000	323,000 r/	315,000
Secondary e/	10,000	10,000	10,000	10,000 r/	10,000
Total	202,000	205,000	314,000	333,000 r/	325,000
Austria, secondary	41,000	44,800	49,500	47,300 r/	51,600 4/
Belgium: e/					
Primary	1,500	1,000	800	800 r/	1,000
Secondary	103,000	105,000	102,000 r/	102,000	103,000
Total	105,000	106,000	103,000	103,000 r/	104,000
Brazil, primary	152,000	141,000	158,000 r/	161,000 r/	160,000
Bulgaria: e/					
Primary	29,300	26,800	24,000	24,000	24,000
Secondary	1,000	1,000	1,000	1,000	1,000
Total	30,300	27,800	25,000	25,000	25,000
Canada:					
Primary	476,000	505,000	515,000	518,000 r/	515,000 4/
Secondary	47,400	26,800 r/	37,400	44,100 r/	45,000
Total	523,000	532,000 r/	552,000	562,000 r/	560,000
Chile, primary 5/	1,210,000	1,180,000	1,190,000	1,240,000	1,280,000
China, primary e/	359,000 r/	385,000 r/	418,000 r/	443,000 r/	480,000
Czech Republic, primary	XX	XX	XX	500	--
Czechoslovakia: 6/					
Primary e/	5,000	5,000	5,000	XX	XX
Secondary e/	3,200	3,000	3,000	XX	XX
Total	8,200	8,000	8,000	XX	XX
Finland:					
Primary	90,200	90,100	111,000 r/	107,000 r/	98,200 4/
Secondary e/	12,000	12,000	12,000	12,000	12,000
Total e/	102,000	102,000	123,000 r/	119,000 r/	110,000
France, secondary e/	6,600	5,800	6,100	5,900 r/	5,880
Germany:					
Primary:					
Eastern states	20,000 r/	XX	XX	XX	XX
Western states	180,000 r/	XX	XX	XX	XX
Total primary	200,000 r/	186,000 r/	165,000 r/	141,000 r/	237,000 4/
Secondary, western states e/	75,900 r/	70,000	70,000	60,000 r/	54,800 4/
Grand total e/	XX	256,000 r/	235,000 r/	201,000 r/	292,000 4/
Hungary, secondary e/	100	100	100	100	100
India, primary	40,700	45,500 r/	47,700 r/	37,000 r/	50,300
Iran: 7/					
Primary	54,800 r/	81,900 r/	86,400 r/	85,000 r/	125,000 4/
Secondary e/	4,600	6,300	6,400	7,000	8,000
Total e/	59,400 r/	88,200 r/	92,800 r/	92,000 r/	133,000
Japan:					
Primary	893,000	968,000	1,050,000	1,100,000 r/	1,030,000 4/
Secondary	147,000	118,000	129,000	85,700 r/	96,500 4/
Total	1,040,000	1,090,000	1,170,000	1,180,000 r/	1,120,000 4/
Kazakhstan: e/					
Primary	XX	XX	300,000 r/	300,000 r/	275,000
Secondary	XX	XX	20,000 r/	20,000 r/	20,000
Total	XX	XX	320,000 r/	320,000 r/	295,000
Korea, North: e/					
Primary	25,000	20,000	21,000	23,000	23,000
Secondary	5,000	5,000	5,000	5,000	5,000
Total	30,000	25,000	26,000	28,000	28,000
Korea, Republic of, primary	161,000	149,000	170,000	142,000 e/	160,000
Mexico, primary	175,000	183,000	228,000	282,000 r/	277,000 4/
Namibia, primary 8/	33,200	33,500 r/	37,500	34,800 e/	30,100 4/
Norway, primary	36,500	38,400	39,300	37,200 r/	39,400 4/

See footnotes at end of table.

TABLE 11--Continued
COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Oman, primary	12,100	12,200	15,000	27,700	24,200
Peru, primary	196,000	269,000	254,000	238,000 r/	244,000
Philippines, primary	153,000 r/	167,000 r/	169,000	171,000 r/	168,000
Poland:					
Primary e/	331,000	353,000	363,000	360,000	360,000
Secondary e/	20,000	20,000	20,000	20,000	20,000
Total	351,000	373,000	383,000	380,000	380,000
Portugal, secondary e/	2,000	2,000	1,000	1,000	1,200
Romania:					
Primary e/	27,300	27,800	27,400 r/	25,000 r/	23,000
Secondary e/	1,000	1,000	1,000	1,000	5,000
Total	28,300	28,800	28,400 r/	26,000 r/	28,000
Russia: e/					
Primary	XX	XX	706,000 r/	589,000 r/	579,000
Secondary	XX	XX	10,000 r/	10,000 r/	10,000
Total	XX	XX	716,000 r/	599,000 r/	589,000
Serbia and Montenegro:					
Primary	XX	XX	80,000 r/	44,100 r/	60,000
Secondary	XX	XX	48,000 r/	13,300 r/	20,000
Total	XX	XX	128,000 r/	57,400 r/	80,000
Slovakia, primary e/	XX	XX	XX	3,000	3,000
South Africa, Republic of, primary	176,000	165,000	159,000 r/	157,000 r/	166,000 4/
Spain:					
Primary	118,000 r/	111,000	110,000	136,000 r/	142,000 4/
Secondary	32,000 r/	38,000	40,000	37,300 r/	46,800 4/
Total	150,000	149,000	150,000	173,000 r/	188,000 4/
Sweden:					
Primary	76,400	68,100	77,800	76,300	79,100
Secondary	31,600	29,400	20,600	22,100	19,600
Total	108,000	97,600	98,400	98,400	98,700
Taiwan, primary	16,100	--	--	--	--
Turkey, undifferentiated 9/	25,200 r/	32,400 r/	31,600 r/	39,600 r/	36,000
U.S.S.R.: e/ 10/					
Primary	1,370,000 r/	1,360,000 r/	XX	XX	XX
Secondary	110,000 r/	50,000 r/	XX	XX	XX
Total	1,480,000 r/	1,410,000 r/	XX	XX	XX
United States:					
Primary 11/	1,160,000	1,120,000	1,180,000	1,270,000	1,310,000 4/
Secondary	305,000	364,000	394,000	415,000	397,000 4/
Total	1,460,000	1,490,000	1,570,000	1,680,000	1,710,000 4/
Uzbekistan: e/					
Primary	XX	XX	70,000 r/	65,000 r/	50,000
Secondary	XX	XX	5,000 r/	5,000 r/	5,000
Total	XX	XX	75,000 r/	70,000 r/	55,000
Yugoslavia: 12/					
Primary	106,000	95,800 r/	XX	XX	XX
Secondary	68,300	58,700 r/	XX	XX	XX
Total	174,000	155,000	XX	XX	XX
Zaire, primary:					
Electrowon	229,000	180,000	111,000	50,000 e/	50,000
Other	117,000	52,500	19,900	10,000 e/	10,000
Total	346,000	233,000	131,000	60,000 e/	60,000
Zambia, primary: 13/					
Electrowon	51,900	64,500	64,000	62,400 r/	62,400 4/
Other	332,000	300,000	356,000	305,000 r/	318,300 4/
Total	384,000	365,000	420,000	368,000 r/	381,000 4/

See footnotes at end of table.

TABLE 11--Continued
COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Zimbabwe, primary 14/	14,100	13,830	9,700	8,200	10,000
Total primary:					
Electrowon	281,000	245,000	175,000 r/	112,000 r/	112,000
Other	8,340,000 r/	8,360,000 r/	8,470,000 r/	8,480,000 r/	8,670,000
Total secondary	1,030,000 r/	971,000 r/	990,000 r/	925,000 r/	937,000
Total undifferentiated	25,200	32,400	31,600	39,600	36,000
Grand total	9,680,000 r/	9,600,000 r/	9,660,000 r/	9,560,000 r/	9,750,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ This table includes total production of copper metal at the unrefined stage, including low-grade cathode produced by electrowinning methods. The smelter feed may be derived from ore, concentrates, copper precipitate or matte (primary), and/or scrap (secondary). To the extent possible, primary and secondary output of each country is shown separately. In some cases, total smelter production is officially reported, but the distribution between primary and secondary has been estimated. Table includes data available through July 17, 1995.

3/ Argentina presumably produces some smelter copper utilizing its own small mine output together with domestically produced cement copper, and possibly using other raw materials including scrap, but the levels of such output cannot be reliably estimated.

4/ Reported figure.

5/ Data revised to exclude high-grade electrowon production. Data include low-grade electrowon which is re-refined.

6/ Dissolved Dec. 31, 1992.

7/ Data are for year beginning Mar. 21 of year stated. Secondary production is estimated to be about 5% of total.

8/ Includes products of imported concentrate.

9/ Secondary production is estimated to be about 5% to 10% of total.

10/ Dissolved in Dec. 1991.

11/ Figures for U.S. primary smelter production may include a small amount of copper derived from precipitates shipped directly to the smelter for further processing; production derived from electrowinning and fire-refining is not included. Copper content of precipitates shipped directly to smelter are as follows, in metric tons: 1990--23,000; 1991--27,700; 1992--27,200; 1993--19,000; and 1994--26,400.

12/ Dissolved in Apr. 1992.

13/ For fiscal year beginning Apr. 1 of year stated. Electrowon is total electrowon production reported, less the quantity reported as "finished production, leach cathodes."

14/ Includes impure cathodes produced by electrowinning in nickel processing.

TABLE 12
COPPER: WORLD REFINERY PRODUCTION, 1/ 2/ BY COUNTRY

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Albania, primary e/	10,900	4,400	90	100	100
Argentina, secondary e/	10,900 r/	12,000 r/	15,000	15,000	15,000
Australia:					
Primary	250,000	244,000	271,000 r/	285,000 r/	312,000 3/
Secondary	24,000	35,000	32,000	24,000 r/	24,000 3/
Total	274,000	279,000	303,000 r/	309,000 r/	336,000 3/
Austria:					
Primary	8,690	8,080	5,710	5,870 r/	3,040 3/
Secondary	41,000	44,800	49,000	46,900 r/	47,400 3/
Total	49,700	52,800	54,700	52,700 r/	50,500 3/
Belgium: 4/					
Primary	230,000	192,000	213,000 r/	276,000 r/	267,000
Secondary	102,000	106,000	103,000 r/	103,000 r/	104,000
Total	332,000	298,000	316,000 r/	379,000 r/	371,000
Brazil:					
Primary	152,000	141,000	158,000 r/	161,000 r/	160,000
Secondary	49,600	37,000	52,200 r/	54,000 r/	55,000
Total	202,000	178,000	210,000 r/	215,000 r/	215,000
Bulgaria:					
Primary	14,300	7,850	13,000 r/	11,800 r/	21,000
Secondary	10,000	5,000	5,000 e/	5,000 e/	5,000
Total	24,300	12,800	18,000 r/ e/	16,800 r/ e/	26,000
Canada:					
Primary	468,000	504,000	508,000	520,000	505,000
Secondary	47,400	34,500	31,100	41,600	45,000
Total	516,000	538,000	539,000	562,000	550,000 3/
Chile, primary	1,190,000	1,230,000	1,240,000	1,270,000 r/	1,280,000
China: e/					
Primary	400,000	400,000	430,000	485,000 r/	440,000
Secondary	160,000	160,000	229,000	245,000 r/	244,000
Total	560,000	560,000	659,000	730,000 r/	684,000
Czech Republic, primary	XX	XX	XX	500	--
Czechoslovakia: 5/					
Primary e/	8,000	10,000	8,000	XX	XX
Secondary e/	17,400	15,900	20,600	XX	XX
Total	25,400	25,900	28,600	XX	XX
Egypt, secondary e/	3,600	3,600	3,600	3,600	3,600
Finland:					
Primary	63,100 r/	61,500 r/	65,900 r/	67,700 r/	58,400 3/
Secondary	2,000 r/	3,000 r/	5,000 r/	6,000 r/	10,800 3/
Total	65,100	64,500	70,900 r/	73,700 r/	69,200 3/
France:					
Primary e/	18,000	19,600	27,700 3/	21,100 r/	20,200
Secondary e/	26,000	30,000	29,000	23,300 r/	21,500
Total e/	44,000	49,600	56,700	44,400 r/	41,700
Germany:					
Primary:					
Eastern states e/	39,900	XX	XX	XX	XX
Western states	204,000	XX	XX	XX	XX
Subtotal	244,000	203,000	236,000	271,000 r/	253,000
Secondary:					
Eastern states e/	16,800	XX	XX	XX	XX
Western states	272,000	XX	XX	XX	XX
Subtotal e/	289,000	318,000	345,000	361,000 r/	339,000
Total:					
Eastern states e/	56,700	XX	XX	XX	XX
Western states	476,000	XX	XX	XX	XX
Grand total	533,000	522,000	582,000	632,000 r/	592,000 3/
Hungary, primary and secondary e/	12,800 3/	12,000	12,000	11,000	11,000
India, primary:					
Electrolytic	40,600	46,200 r/	44,300 r/	36,300 r/	48,300 3/
Fire refined e/	1,000	1,000	1,000	500	500
Total e/	41,600	47,200 r/	45,300 r/	36,800 r/	48,800

See footnotes at end of table.

TABLE 12--Continued
COPPER: WORLD REFINERY PRODUCTION, 1/ 2/ BY COUNTRY

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Iran, primary 6/ 7/	47,800 r/	79,700 r/	102,000 r/	84,900 r/	64,000 3/
Italy, primary and secondary	83,000	82,500 e/	76,000 e/	90,300 r/	94,000
Japan:					
Primary	893,000	968,000	1,050,000	1,100,000 r/	1,030,000 3/
Secondary	115,000	109,000	115,000	89,700 r/	93,700 3/
Total	1,010,000	1,080,000	1,160,000	1,190,000	1,120,000 3/
Kazakhstan: e/					
Primary	XX	XX	310,000 r/	310,000 r/	282,000 3/
Secondary	XX	XX	20,000 r/	20,000 r/	20,000 3/
Total	XX	XX	330,000 r/	330,000 r/	302,000 3/
Korea, North: e/					
Primary	25,000	19,000	20,000	22,000	22,000
Secondary	10,000	5,000	5,000	5,000	5,000
Total	35,000	24,000	25,000	27,000	27,000
Korea, Republic of:					
Primary	183,000 e/	202,000	209,000	218,000 e/	222,000
Secondary e/	2,560	1,000	2,000	2,000	2,000
Total	186,000	203,000	211,000	220,000 e/	224,000
Mexico:					
Primary:					
Electrowon	26,900	32,100	27,900	30,000 e/	26,900 3/
Other	94,900 r/	73,900 r/	82,600 r/	73,800 r/	96,500 3/
Secondary	31,200 r/	53,000	80,500 r/	77,200 r/	78,600 3/
Total	153,000 r/	159,000 r/	191,000 r/	181,000 r/	202,000 3/
Norway, primary 7/	36,500	38,400	39,300	37,200 r/	39,400 3/
Oman, primary	12,000	11,400	16,200	20,500	22,000
Peru, primary	228,000 r/	286,000 r/	276,000 r/	278,000 r/	280,000
Philippines, primary	126,000	115,000	146,000	172,000 e/	153,000 3/
Poland, primary 7/	346,000	379,000	387,000	404,000	405,000
Portugal, primary	1,000	300	--	--	--
Romania: e/					
Primary	40,300	29,800	21,000	22,000 r/	22,100
Secondary	4,000	4,000	3,080	3,000	4,600
Total	44,300	33,800	24,100	25,000 r/	26,700
Russia:					
Primary e/	XX	XX	525,000 r/	522,000 r/	500,000
Secondary e/	XX	XX	50,000	40,000 r/	50,000
Total	XX	XX	575,000 r/	562,000 r/	550,000 3/
Serbia and Montenegro:					
Primary	XX	XX	78,600 r/	43,400 r/	61,000
Secondary	XX	XX	36,200 r/	7,890 r/	11,100
Total	XX	XX	115,000	51,300 r/	72,100
Slovakia , primary and secondary	XX	XX	XX	28,000	28,000
South Africa, Republic of, primary 7/	133,000	127,000	120,000 r/	128,000 r/	130,000 3/
Spain:					
Primary	116,000 e/	111,000	134,000	137,000 r/	142,000
Secondary	50,000 e/	38,000	44,800	42,000 r/	46,800
Total	166,000 e/	149,000	179,000	179,000 r/	188,000
Sweden:					
Primary	66,300	67,600	71,600	76,300	77,300
Secondary e/	31,000	29,000	30,000	22,500 3/	25,800 3/
Total	97,300	96,600	102,000	98,800	103,000
Taiwan:					
Primary	16,100	--	--	--	--
Secondary e/	6,000	12,000	12,000	10,000	10,000
Total e/	22,100	12,000	12,000	10,000	10,000
Turkey, primary	84,200	80,800	104,000 r/	92,400	100,000
U.S.S.R.: e/ 8/					
Primary	1,100,000	950,000	XX	XX	XX
Secondary	130,000	120,000	XX	XX	XX
Total	1,230,000	1,070,000	XX	XX	XX

See footnotes at end of table.

TABLE 12--Continued

COPPER: WORLD REFINERY PRODUCTION, 1/ 2/ BY COUNTRY

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
United Kingdom:					
Primary	47,000	16,600	10,400 e/	10,600 r/	11,100 3/
Secondary	74,600	53,500	31,700 e/	35,900 r/	35,600 3/
Total	122,000	70,100	42,100 e/	46,600 r/	46,700 3/
United States:					
Primary:					
Electrowon	393,000	441,000	502,000	491,000	493,000 3/
Other	1,180,000	1,140,000	1,210,000	1,300,000	1,340,000 3/
Secondary	441,000	418,000	433,000	460,000	392,000 3/
Total	2,020,000	2,000,000	2,140,000	2,250,000	2,230,000 3/
Uzbekistan: e/					
Primary	XX	XX	70,000 r/	65,000 r/	50,000
Secondary	XX	XX	5,000 r/	5,000 r/	5,000
Total	XX	XX	75,000 r/	70,000 r/	55,000
Yugoslavia: 9/					
Primary	102,000	107,000	XX	XX	XX
Secondary	49,200	27,000 e/	XX	XX	XX
Total	151,000	134,000	XX	XX	XX
Zaire, primary 10/	141,000	104,000	47,500	40,000	24,000
Zambia, primary: 11/					
Electrowon	52,700	45,400	43,700	48,800 r/	49,200 3/
Other	385,000	357,000	428,000	363,000 r/	320,000 3/
Total	438,000	402,000	472,000	412,000 r/	370,000 3/
Zimbabwe: 12/					
Primary	14,100	13,800	9,670	8,190	10,000
Secondary e/	8,400	8,200	8,200	8,200	6,000
Total e/	22,500	22,000	17,900	16,400	16,000
Total primary	8,860,000 r/	8,740,000 r/	9,140,000 r/	9,380,000 r/	9,160,000
Total secondary	1,740,000 r/	1,680,000 r/	1,800,000 r/	1,760,000 r/	1,700,000
Total primary and secondary, undifferentiated	229,000 r/	222,000 r/	208,000 r/	257,000 r/	263,000
Grand total	10,800,000	10,600,000	11,100,000 r/	11,400,000	11,100,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ This table includes total production of refined copper, whether produced by pyrometallurgical or electrolytic refining methods and whether derived from primary unrefined copper or from scrap. Copper cathode derived from electrowinning processing is also included. Table includes data available through July 17, 1995.

3/ Reported figure.

4/ Includes leach cathode from Zaire, which is processed.

5/ Dissolved Dec. 31, 1992.

6/ Data are for Iranian years beginning Mar. 21 of that stated.

7/ May include secondary.

8/ Dissolved in Dec. 1991.

9/ Dissolved in Apr. 1992.

10/ Excludes leach cathode exported for reprocessing in Belgium.

11/ Data are for fiscal year beginning Apr. 1 of that stated. Electrowon covers only presumably high-grade electrowon cathodes reported as "finished production leach cathodes." Other, in addition to electrorefined cathodes, includes a smaller amount of "finished product shapes" presumably cast from electrorefined cathodes, high-grade electrowon cathodes, or any blister-anodes and low-anodes and low-grade electrowon cathodes that were furnace- or fire-refined.

12/ May not include copper-nickel matte (copper content more than 6,000 tons per year) imported from Botswana for toll refining.

INDUSTRIAL DIAMOND

By Gordon T. Austin

Industrial diamond is natural diamond that does not meet the standards of gem diamond because of its color, size, or other imperfection. Also, it may be a synthetic diamond that is tailor-made for industrial applications.

Legislation and Government Programs

The National Defense Stockpile (NDS) for industrial diamonds, as of December 31, 1994, had a goal of zero and an inventory of 2.5 million carats for crushing bort. The goal for industrial stones was 3.0 million carats and the inventory was 5.54 million carats. There is currently legislative authority for disposal of 4.0 million carats of bort and 3.0 million carats of industrial stones. The inventory of small diamond dies was about 25,500 pieces compared with a goal of zero pieces; but no disposal authorization was issued.

Production

The United States was the largest producer of synthetic industrial diamond. This has made the United States independent of foreign sources for crushing bort or similar diamond except for grit sizes larger than about 20 mesh. Having no production of natural diamond, it was dependent on other countries for its natural diamond supply.

Three domestic firms produced synthetic industrial diamond in the United States: Du Pont Industrial Diamond Div., Gibbstown, NJ; General Electric Co., GE Superabrasives, Worthington, OH; and Suprahards, Inc. Cedar Knolls, NJ. Three firms, Megadiamond Industries Inc., a subsidiary of Smith International Inc., Provo, UT., U.S. Synthetics Corp., Orem, UT; and Temple Technology of New Jersey manufactured polycrystalline diamond from purchased synthetic diamond grit. The firms had the capability to manufacture synthetic industrial diamond grit, but chose not to for economic reasons. Publishing production data would disclose company proprietary data. Domestic production did increase significantly. The United States continued to be the largest single producer of synthetic industrial diamond, a role it has enjoyed since 1957.

U.S. secondary production of industrial diamond was from six firms. They were Amplex Corp., Worcester, MA; American Boarts Crushing, Boca Raton, FL; Diamondsharp Corp., Keene, NH; Industrial Diamond Laboratory Inc., Bronx, NY; Industrial Diamond Powders Co., Pittsburgh, PA; International Diamond Services Inc., Houston, TX; and National Research Co., Fraser, MI. The firms reclaimed a total of about 16.1 million carats from used drill bits, diamond tools, and wet and dry diamond-containing waste.

Consumption

The United States continued to be the largest single consumer of industrial diamond. The U.S. Bureau of Mines estimate of apparent consumption of industrial diamond was approximately 154 million carats, a slight increase compared with 1993 consumption.

The principal uses of industrial diamond stones are in drilling bits and reaming shells, single- or multiple-point diamond tools, diamond saws, diamond wheels, abrasive and diamond wire-drawing dies. Miscellaneous uses include: engraving points, glass cutters, bearings, surgical instruments and special tools. Changes in technology and conventional wisdom have resulted in an increased use of synthetic industrial diamonds and polycrystalline diamond shapes (PDS) and compacts (PDC) for many of the uses listed above. There has been an increased use of PDS, PDC, and matrix set synthetic diamond grit in drilling bits and reaming shells in the last three years. Diamond saws, diamond wheels, and diamond abrasive grit and powder are almost exclusively made from synthetic diamond. PDS and PDC are used in the manufacture of single- and multiple-point tools and PCD is used in a majority of the diamond wire-drawing dies.

Mineral, oil, and gas exploration were the primary uses of drilling bits and shells. Foundation testing for dams, buildings, and other construction also used diamond bits and shells, as did masonry drilling in buildings for conduits and access and testing of concrete in various structures and other similar applications. The primary uses of diamond tools were for dressing and trueing grinding wheels and for cutting, machining, boring, and finishing. Beveling glass automobile windows also was a use. Cutting dimension stone, ceramics, and concrete in highway reconditioning were the major uses of diamond saws. The forming of refractory shapes for furnace linings also uses diamond saws. Diamond wire dies were essential for high-speed drawing of fine wire, especially from hard, high-strength metals and alloys.

Diamond grit, powders, and fragmented bort go into diamond grinding wheels, saws, impregnated bits and tools, and loose abrasives compounds for lapping and polishing.

Three major types of grinding wheels were made--resinoid, metal, and vitrified bonds--in many shapes and sizes designed for specific applications. The sizes range up to 1 meter in diameter for very large industrial wheels. Sharpening and shaping of carbide machine tool tips, grinding of dies, edging of plate glass, and optical grinding were among the primary applications of diamond grinding wheels. The cutting of concrete, stone, ceramics, and composite materials were uses of saws made with diamond grit. Very fine saws sliced wafers from brittle metals and crystals for use in electronic and electric devices.

Finishing optical surfaces, jewel bearings, gem stones, wiredrawing dies, cutting tools, and metallographic specimens were the primary uses of polishing and lapping powder and compounds. Hundreds of other important items made from metals, ceramics, plastics, and glass also were finished with diamond compounds.

Prices

The Bureau does not collect price data on industrial diamonds. The Bureau did track the average import value of various classifications of industrial diamonds. The average value of U.S. imports of natural grit and powder, synthetic grit and powder, and industrial stones was $0.87 per carat, $0.49 per carat, and $9.41, respectively.

Foreign Trade

The United States was the largest exporter of industrial diamond grit and powder in the world. The United States exported and reexported a record 153 million carats of natural and synthetic grit and powder, an increase of 43% over the record set in 1993. The material was worth a record $143 million. Additionally, the U.S. exported and reexported approximately 4.4 million carats of industrial stones, valued at $89.6 million.

Imports of dust, grit, and powder in 1994 were a record high 174 million carats, about 31% more than those in 1993. The 1994 imports of diamond stones were 2.8 million carats, about 46% less than 1993 imports. *(See tables 1 and 2.)*

Outlook

Synthetic industrial diamond production is significantly larger than the production of natural industrial diamonds. The countries that have synthetic diamond production, in declining order are; the United States, Ireland, Russia, South Africa, China, Germany, Japan, Sweden, Republic of Korea, Czechoslovakia, Romania, France, and Greece.

Diamond grit and powder should experience substantial increases in domestic demand for every end use during the next 5 years. The increases for synthetic grit and powder are expected to be greater than for natural. The constant-dollar prices of these materials, especially the synthetic diamond products, should continue to decrease or at least remain constant. This is because planned production increases will make them more cost-effective. The contract construction industry is an area in which the greatest increases will occur. This is because large quantities of saw-grade diamond will be required for highway and bridge repair and replacement. Large increases also are expected in the dimension stone industry as a cutting and polishing media. The stone, clay, and glass industries will increase their uses in cutting, shaping, and polishing media. Additionally, polycrystalline synthetic diamond compacts and shapes will continue to displace natural diamond stone and tungsten carbide drill bits in the mineral services sector. The probable average annual growth rate in U.S. production is about 10%, based on estimates by the U.S. producers. U.S. production of synthetic material is sufficient to supply U.S. diamond grit and powder demand. The United States will continue to be a major exporter.

The major domestic end use for industrial stones in the next 5 years will continue to be in the oil, gas, and mineral industries. These stones are natural and cannot yet be manufactured commercially. Polycrystalline synthetic diamond compacts and shapes have had a major negative impact on the natural industrial diamond stone markets. This will limit the growth of U.S. demand for stone during the next 5 years. U.S. consumption should average between 6 and 7 million carats per year for the next 5 years. Approximately 50% of the potential natural stone applications will be replaced by the synthetic compacts and shapes by the year 2000. *(See table 3.)*

Other Sources

U.S. Bureau of Mines Publications
Diamonds (Idustrial) Ch. Mineral Commodity Summaries, 1995
Abrasive Materials Annual Report, 1993
Mineral Facts and Problems, 1985

TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL DIAMOND STONES, BY COUNTRY 1/

(Thousand carats and thousand dollars)

Country	National industrial diamond stones (including glazers' and engraver's diamond unset) (7102.21.3000 and .4000)				Miners' diamond, natural and synthetic (7102.21.1010 and .1020)			
	1993		1994		1993		1994	
	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/
Belgium	96	420	84	683	528	6,710	453	3,830
China	39	34	2	2	--	--	(3/)	3
Ghana	236	3,300	101	1,990	6	300		
India	76	58	9	19	22	5	--	--
Ireland	169	536	90	120	94	269	30	194
Japan	9	82	(3/)	3	2	118	1	36
Netherlands	47	2,190	2	1,810	203	2,290	118	1,270
South Africa, Republic of	23	81	37	118	(3/)	38	--	--
Switzerland	(3/)	5	(3/)	2	256	947	272	885
United Kingdom	1,560	7,120	843	6,780	422	3,860	291	3,620
Zaire	960	3,780	80	838	115	2,380	238	3,410
Other	62	682	68	310	276	467	86	480
Total	3,280	18,300	1,320	12,700	1,920	17,400	1,490	13,700

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Customs value.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF DIAMOND POWDER, DUST AND GRIT, BY COUNTRY 1/

(Thousand carats and thousand dollars)

Country	Diamond powder and dust, synthetic (7105.10.0020; 0030 and .0050)				Diamond powder and dust, natural (7105.1011 and .0015)			
	1993		1994		1993		1994	
	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/
Belgium	383	652	1,050	1,920	1,250	2,730	772	1,860
China	5,140	1,710	4,920	735	43	35	1,630	272
Germany	11,900	9,690	22,200	4,630	101	157	522	574
Hong Kong	48	22	3,390	1,080	302	53	60	13
India	--	--	38	19	34	31	18	8
Ireland	76,400	45,800	95,400	60,000	4,090	5,890	3,310	4,100
Japan	3,730	2,660	3,170	2,220	132	189	2	4
Korea, Republic of	2,920	1,020	5,290	3,940	15	35	841	270
Russia	10,600	1,760	17,700	2,010	90	67	217	227
South Africa, Republic of	389	111	56	31	3	2	--	--
Switzerland	2,540	2,340	509	282	368	113	450	155
Ukraine	6,840	988	5,370	468	2	2	--	--
United Kingdom	2,650	2,270	3,190	1,370	836	1,450	1,760	943
Zaire	--	--	30	22	359	234	997	551
Other	1,340	714	1,090	1,070	332	281	400	521
Total	125,000	69,800	163,000	79,800	7,950	11,300	11,000	9,510

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Customs value.

Source: Bureau of the Census.

TABLE 3
NATURAL DIAMOND: WORLD PRODUCTION, BY TYPE AND COUNTRY 1/ 2/

(Thousand carats)

Country	1990			1991		
	Gem 3/	Industrial	Total	Gem 3/	Industrial	Total
Angola 4/	1,060	73	1,130	899	62	961
Australia	17,300	17,300	34,700	18,000	18,000	36,000
Botswana	12,200	5,200	17,400	11,600	4,950	16,500
Brazil	600	900	1,500	600	900	1,500 e/
Central African Republic	303	78	381	296	82	378 r/
China e/	200	800	1,000	200	800	1,000
Gabon e/	400	100	500	400	100	500
Ghana	520	130	650	560	140	700
Namibia	750	15	763	1,170	20	1,190
Russia e/	XX	XX	XX	XX	XX	XX
Sierra Leone 5/	66	12	78	160	83	243
South Africa, Republic of	3,900 r/	4,800 r/	8,710	3,800 r/	4,600 r/	8,430
U.S.S.R. e/ 6/	12,000	12,000	24,000	10,000	10,000	20,000
Venezuela	85	248	333	102	112	214
Zaire	2,910	16,500	19,400	3,000	14,800	17,800
Total	48,400	53,400	102,000	46,900	50,000	97,000
Other	4,180	4,950	9,100	4,080	4,770	8,870
Grand total	52,600 r/	58,400 r/	111,000 r/	51,000 r/	54,800	106,000 r/
	1992			1993		
	Gem 3/	Industrial	Total	Gem 3/	Industrial	Total
Angola 4/	1,100	80	1,180	130 r/	15 r/	145 r/
Australia	18,100 r/	22,100 r/	40,200 r/	18,800 r/	23,000 r/	41,900 r/
Botswana	11,200	4,790	15,900	10,300 r/	4,420 r/	14,700 r/
Brazil	653	665	1,320	600	900	1,500 e/
Central African Republic	307	107	414	370 r/	125 r/	495 r/
China e/	200	800	1,000	230	850	1,080
Gabon e/	400	100	500	400	100	500
Ghana	570	140	710	570 r/	140 r/	710 r/ e/
Namibia	1,520 r/	30 r/	1,550	1,120 r/	20 r/	1,140
Russia e/	9,000	9,000	18,000	8,000	8,000	16,000
Sierra Leone 5/	180 r/	116 r/	296	90	68	158
South Africa, Republic of	4,600 r/	5,600 r/	10,200 r/	4,600 r/	5,700 r/	10,300
U.S.S.R. e/ 6/	XX	XX	XX	XX	XX	XX
Venezuela	302	176	478	145 r/	155 r/	301 r/
Zaire	8,930	4,570	13,500	2,010 r/	13,600 r/	15,600 r/
Total	52,400	42,700	95,100	42,800	51,400	94,300
Other	4,880	5,800	11,300	4,860	5,900	10,800
Grand total	57,300 r/	48,500 r/	106,000 r/	47,700 r/	57,300 r/	105,000 r/

See footnotes at the end of table.

TABLE 3--Continued

NATURAL DIAMOND: WORLD PRODUCTION, BY TYPE AND COUNTRY 1/ 2/

(Thousand carats)

Country	1994 e/		
	Gem 3/	Industrial	Total
Angola 4/	270	30	300
Australia	19,500	23,800	43,300
Botswana	11,000	5,000	16,000
Brazil e/	600	900	1,500
Central African Republic	370	125	495
China e/	230	850	1,080
Gabon e/	400	100	500
Ghana	580	145	725
Namibia	1,280	30	1,310 7/
Russia e/	8,500	8,500	17,000
Sierra Leone 5/	155	100	255
South Africa, Republic of	5,000	5,800	10,600 7/
U.S.S.R. e/ 6/	XX	XX	XX
Venezuela	220	175	395
Zaire	4,000	13,000	17,000
Total	47,100	52,800	99,900
Other	5,230	5,910	11,200
Grand total	52,300	58,700	111,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data have been rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 30, 1995. Total natural diamond output (gem plus industrial) for each country actually is reported, except where indicated by a footnote to be estimated. In contrast, the detailed separate production data for gem diamond and industrial diamond are U.S.Bureau of Mines estimates except Brazil (1990) and Central African Republic (1990-93), for which source publications give details on grade as well as totals. The estimated distribution of total output between gem and industrial diamond is conjectural, and for most countries, is based on the best available data at time of publication.

3/ Includes near-gem and cheap-gem qualities.

4/ Figures do not include smuggled artisanal production.

5/ Figures are estimates based on reported exports and do not include smuggled diamonds.

6/ Dissolved in Dec. 1991.

7/ Reported figure.

TABLE 4
SYNTHETIC DIAMOND: WORLD PRODUCTION, BY COUNTRY1/ 2/

(Thousand carats)

Country	1990	1991	1992	1993	1994 e/
Belarus e/	XX	XX	30,000	30,000	25,000
China e/	15,000	15,000	15,000	15,500	15,500
Czech Republic	XX	XX	XX	5,000 e/	5,000
Czechoslovakia e/ 3/	10,000	10,000	10,000	XX	XX
France e/	5,000	4,000	3,500	3,500	3,500
Greece e/	1,000	1,000	750	1,000	1,000
Ireland e/	60,000	60,000	60,000	66,000	65,000
Japan e/	25,000	30,000	30,000	32,000	32,000
Romania e/	3,000	3,000	5,000 r/	5,000 r/	5,000
Russia e/	XX	XX	80,000	80,000	80,000
Serbia and Montenegro	XX	XX	5,000	5,000	5,000
Slovakia	XX	XX	XX	5,000	5,000
South Africa, Republic of e/	60,000	60,000	60,000	60,000 r/	60,000
Sweden e/	25,000	25,000	25,000	25,000	25,000
U.S.S.R. e/ 4/	120,000	120,000	XX	XX	XX
Ukraine e/	XX	XX	10,000	10,000	8,000
United States	W	90,000	90,000	103,000	104,000
Yugoslavia e/ 5/	5,000	5,000	XX	XX	XX
Total	329,000 r/	423,000	424,000 r/	446,000 r/	439,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 30, 1995.

3/ Dissolved Dec. 31, 1992.

4/ Dissolved in Dec. 1991.

5/ Dissolved in Apr. 1992.

DIATOMITE

By Harold A. Taylor, Jr.

U.S. sales of processed diatomite increased slightly to 613,000 metric tons, valued at $152 million, according to the U.S. Bureau of Mines. The major use of diatomite was in filtration to separate suspended solids in liquids.

Production

Five companies processed diatomite at 11 plants in 4 States. California continued to be the leading State followed by Nevada, Oregon, and Washington. Major domestic producers were Celite Corp., with operations at Lompoc, CA, and Quincy, WA; Eagle-Picher Minerals Inc. at Lovelock and Sparks, NV, and Vale, OR; and Grefco Inc., Dicalite Div. at Burney and Lompoc, CA and Mina, NV. Other producers were CR Minerals Corp., Fernley, NV; and Oil-Dri Production Co., Christmas Valley, OR.

Diatomite production data were collected from voluntary surveys of all 11 known operations. All responded representing 100% of the production data shown in table 1.

Consumption

Apparent domestic consumption of processed diatomite increased 5% to 456,000 metric tons. In 1994, domestic and export sales of filter-grade diatomite were 447,000 tons, 5% more than in 1993. Sales of diatomite as a filler, the second largest use, were about 86,000 tons, 15% less than in 1993.

Price

The average unit value of sales for processed diatomite was $248 per ton, 1% less than in 1993.

Foreign Trade

U.S. exports of processed diatomite were 157,000 tons, about 5% less than in 1993. The average unit value of exported diatomite was $361 per ton compared with $303 per ton in 1993. Diatomite was exported to 74 countries, of which Canada received 23,950 tons; France, 13,495; Japan, 15,777 tons; Germany, 14,928 tons; and Australia, 10,459 tons; which combined received 50% of the total exported. U.S. exports represented 26% of domestic production. Imports of diatomite were 379 tons, of which 22% was supplied by Mexico.

World Review

World production was estimated to be 1.4 million tons in 1994. The United States remained the world's leading producer followed by France, the former U.S.S.R, and the Republic of Korea. These four countries accounted for 73% of world production.

Outlook

Diatomite consumption is expected to increase slightly over the next few years. Filtration will continue to be the major end use.

TABLE 1
DIATOMITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES 1/

(Thousand metric tons and thousand dollars)

	1993	1994
Domestic production (sales)	599	613
Total value of sales	150,000	152,000

1/ Previously published and 1994 data are rounded by U.S. Bureau of Mines to three significant digits.

TABLE 2
DIATOMITE SOLD OR USED, 1/ BY MAJOR USE

(Percent of U.S. production)

Major use	1993	1994
Fillers	17	14
Filtration	71	73
Insulation	4	3
Other 2/	9	10

1/ Includes exports.

2/ Includes absorbants, additives, and silicates admixtures.

TABLE 3
AVERAGE ANNUAL VALUE PER METRIC TON 1/ OF DIATOMITE, BY MAJOR USE

Major use	1993	1994
Fillers	$287.39	$319.49
Filtration	262.01	237.79
Insulation	153.34	137.38
Other 2/	128.84	259.14
Weighted average	250.67	247.81

1/ Based on unrounded data.

2/ Includes absorbents, additives, and silicate admixtures.

TABLE 4
U.S. EXPORTS OF DIATOMITE 1/

(Thousand metric tons and thousand dollars)

Year	Quantity	Value 2/
1993	165	49,900
1994	157	56,600

1/ Previously published and 1994 data are rounded by U.S. Bureau of Mines to three significant digits.

2/ U.S. Customs.

TABLE 5
DIATOMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Algeria	4	4	4	4 e/	4
Argentina	4 r/	6 r/	5	3 r/	3
Australia e/	10	11	11	11	11
Brazil (marketable) e/	13 3/	13	13	13	13
Canada e/ 4/	4	8	10	10 e/	10
Chile	4	6	6	6 r/	6
Colombia	3	4	4	-- r/	--
Costa Rica e/	4	12	12	12 r/	12
Denmark: e/ 5/					
Diatomite	1	1	1	1 e/	1
Moler	97	95	95	95 e/	95
France e/	250	250	250	250	250
Germany:					
Eastern states	14	XX	XX	XX	XX
Western states	50	XX	XX	XX	XX
Total	64	47	52	52 r/	52
Iceland	26	23	20	19 e/	20
Iran 6/	2	(7/)	(7/) e/	(7/)	(7/)
Italy e/	25	23	26	25	25
Kenya	1	1	1	1 e/	1
Korea, Republic of	55	91	77	67 r/	70
Macedonia 8/	XX	XX	5 r/ e/	5 r/ e/	5
Mexico	51	46	46	46 r/	46
Peru e/	20	26 3/	25	25	25
Portugal e/	2	2	2	2	2
Romania e/	40	30	15	14	14
South Africa, Republic of	3	2	1	-- r/	--
Spain	108	60 e/	36	38 e/	36
Thailand	5	7	10	8 r/	9
U.S.S.R. e/ 9/	250	220	190	150	120
United Kingdom e/	(7/)	(7/)	(7/)	(7/)	(7/)
United States 10/	631	610	595	599	613 3/
Yugoslavia 8/ 11/	6	4 e/	XX	XX	XX
Total	1,680	1,600 r/	1,510	1,460	1,440

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through Apr. 11, 1995.

3/ Reported figure.

4/ Includes an unknown quantity of fuller's earth.

5/ Data represent sales.

6/ Data are for Iranian years beginning Mar. 21 of that stated.

7/ Less than 1/2 unit.

8/ All production in Yugoslavia in 1990-91 came from Macedonia.

9/ Dissolved in Dec. 1991; however, information is inadequate to formulate reliable estimates for individual countries.

10/ Sold or used by producers.

11/ Dissolved in Apr. 1992.

EXPLOSIVES

By Deborah A. Kramer

U.S. production of industrial explosives and blasting agents increased almost 24%, based on producer sales of 2.319 million metric tons. All of the markets for explosives registered an increase, and explosives sales were recorded in all 50 States.

Production

Sales of ammonium nitrate-base explosives increased to 2.280 million tons and represented 98% of U.S. consumption of industrial explosives. High explosives sales rose by 7%, the first sales increase since 1987.

Companies covered by this report, including IME members, are as follows:

* Apache Nitrogen Products Inc.—Benson, AZ
* Arcadian Corp.—Memphis, TN
Austin Powder Co.—Cleveland, OH
* Coastal Chem Inc.—Cheyenne, WY
Amos L. Dolby Co.—Corsica, PA
Dyno Nobel Inc.—Salt Lake City, UT
El Dorado Chemical Co.—St. Louis, MO
The Ensign-Bickford Co.—Simsbury, CT
Explosives Technologies International Inc. (ETI)—Wilmington, DE
ICI Explosives Canada—Ontario, Canada
ICI Explosives USA Inc.—Dallas, TX
LaRoche Industries Inc.—Atlanta, GA
Mining Services International—Salt Lake City, UT
* Nitram Inc.—Tampa, FL
Nitrochem Inc.—Montreal, Quebec, Canada
SENEX Explosives Inc.—Cuddy, PA
Sierra Chemical Co.—Reno, NV
Slurry Explosive Corp.—Oklahoma City, OK
Trojan Corp.—Salt Lake City, UT
* Unocal Corp.—Los Angeles, CA
Viking Explosives and Supply Co.—Rosemount, MN
*Indicates non-IME members.

Consumption

Coal mining was estimated to account for 66% of the total U.S. explosives demand in 1994. Quarrying and nonmetal mining accounted for 13% of demand; metal mining, 11%, construction, 7% and miscellaneous uses, 3%. Coal production in the United States increased by 9.0%, according to the U.S. Department of Energy. The Appalachian, Interior, and Western States all had higher coal production, but the largest increase was in the Western States. According to the Federal Reserve Board production indices, metal mining activity decreased by 1.8% and quarrying and nonmetal mining activity rose by 5.9%. Based on the value of new construction, in constant 1987 dollars, reported by the Economics and Statistics Administration, Bureau of the Census, new construction in 1994 increased by 4.2% from the 1993 level.

Six States, Kentucky, West Virginia, Wyoming, Nevada, Arizona, and Virginia, in declining order, consumed 53% of the total U.S. explosives demand. Three of these States, Wyoming, West Virginia, and Kentucky, in descending order, were the largest coal-producing States, accounting for 54% of total U.S. coal production.

Two companies are involved in creating new uses for explosives and explosives manufacturing facilities. ICI Explosives Environmental was awarded a $370,000 strategic planning contract to evaluate the use of the Volunteer Army Ammunition Plant in Tennessee, which was used to produce trinitrotoluene (TNT). This contract is the first phase in developing a commercial use for the 6,500-acre facility. Alliant Techsystems, in cooperation with Sandia National Laboratories, is working to find way to convert materials such as explosives and liquid rocket fuel into a synthetic fuel gas that can be used to generate electricity or be burned in turbines.[1]

The International Society of Explosives Engineers (SEE) held its annual conference on explosive and blasting technique from January 30 to February 4, 1994. Topics covered at the conference included blasting and productivity, vibration, blast design, blast analysis tools, environmental effects of blasting, and computer blast modeling. Published conference proceedings may be obtained from SEE.

Classification of Industrial Explosives and Blasting Agents.—Apparent consumption of commercial explosives used for industrial purposes in this report is defined as sales reported to the Institute of Makers of Explosives (IME) by members and furnished to the U.S. Bureau of Mines on a proprietary basis, together with sales directly reported to the Bureau by nonmember manufacturers. Commercial explosives imported for industrial uses are included. Certain explosives sales may be concealed under "unprocessed ammonium nitrate" to avoid disclosure of individual company proprietary data.

The principal distinction between high explosives and blasting agents is their sensitivity to initiation. High explosives are cap-sensitive, whereas blasting agents are not. Black powder sales are minor and were last reported by the Bureau in 1971.

The production classifications used in this report are the same as those adopted by IME.

High explosives.—Permissibles—Grades approved by brand name by the Mine Safety and Health Administration (MSHA), as established by U.S. Bureau of Mines testing. Other high explosives—All high explosives except permissibles.

Blasting agents.—Ammonium nitrate-fuel oil (ANFO)—All mixtures, regardless of density. Bulk and packaged slurries, water gels, and emulsions—All bulk and packaged slurries, water gels, emulsions and ANFO mixtures containing slurries, waters gels, and emulsions.

Unprocessed ammonium nitrate—Includes prilled, grained, and water solution (liquor) ammonium nitrate sold for use in the manufacture of commercial explosives.

World Review

ICI Australia announced plans to increase its explosives production at Gladstone, Australia, to 220,000 tons per year. The company planned to spend $30 million to build a new nitric acid plant, thus expanding ammonium nitrate production capacity. The expansion is scheduled to be completed in late 1995.[2]

Outlook

U.S. coal production is expected to increase in 1995, but the increase would not be quite as significant as the increase between 1993 and 1994. The large 1993-94 increase primarily was a consequence of lower coal production in 1993, which resulted from the United Mine Workers of America strike against member companies of the Bituminous Coal Operators' Association early in 1993.

A major factor supporting the rise in U.S. coal production is the rise in demand for coal by electric utilities, which accounted for 88% of total domestic coal consumption in 1994. Although coal consumption in electric utilities was up slightly, the quantity of electricity produced by coal-fired electric powerplants actually declined slightly. This inverse relationship partially reflects the increasing use by electric utilities of low-sulfur Western coal, which is lower in heat content than the coal it is replacing. If coal production increases, demand for explosives also is expected to increase, but at a slower rate. Western States in general have lower coal overburden to matrix ratios and, consequently, higher production efficiencies, thus requiring fewer explosives.

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[1] Chemical Marketing Reporter. Explosives Makers Seek Work in the Wake of the Cold War. V. 246, No. 6, Aug. 8, 1994, p. 4.

[2] European Chemical News. ICI To Lift Queensland Capacity. V. 62, No. 1637, Oct. 3, 1994, p. 29.

TABLE 1
SALIENT STATISTICS OF INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, 1993-94 1/

(Metric tons)

Class	1993	1994
Permissibles	4,430	3,730
Other high explosives	32,300	35,500
Water gels, slurries, and emulsions	277,000	328,000
Ammonium nitrate-fuel oil blasting agents	262,000	463,000
Unprocessed ammonium nitrate	1,300,000	1,490,000
Total	1,880,000	2,320,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 2
INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, BY CLASS AND USE, 1993-94 e/ 1/ 2/

(Thousand metric tons)

Class	Coal mining	Quarrying and nonmetal mining	Metal mining	Construction work	All other purposes	Total
1993:						
Permissibles	4	(3/)	--	(3/)	--	4
Other high explosives	4	14	2	10	2	32
Water gels and slurries	96	97	40	40	4	277
Ammonium nitrate-fuel oil blasting agents	154	52	19	35	2	262
Unprocessed ammonium nitrate	980	79	148	51	42	1,300
Total	1,240	243	209	136	50	1,880
1994:						
Permissibles	4	(3/)	--	(3/)	--	4
Other high explosives	4	14	2	14	2	36
Water gels and slurries	114	115	51	42	6	328
Ammonium nitrate-fuel oil blasting agents	276	91	33	59	5	463
Unprocessed ammonium nitrate	1,140	82	158	53	57	1,490
Total	1,540	302	244	168	70	2,320

e/ Estimated.

1/ Distribution of industrial explosives and blasting agents by consuming industry in 1993 and 1994 estimated from indices of industrial production and economies as reported by the Department of Energy, Federal Reserve Board, Department of Transportation, and Bureau of the Census.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Less than 1/2 unit.

TABLE 3
INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, BY STATES AND CLASS, 1994 1/

(Metric tons)

State	Class					
	Fixed high explosives			Blasting agents		
	Permissible	Other high explosives	Water gels, slurries, and emulsions	Ammonium nitrate-fuel oil blasting agents	Unprocessed ammonium nitrate	Total
Alabama	164	521	2,200	4,230	52,500	59,600
Alaska	--	931	1,690	687	6,530	9,830
Arizona	--	828	20,100	1,410	137,000	159,000
Arkansas	--	433	3,910	4,170	4,470	13,000
California	--	632	4,090	1,460	39,000	45,100
Colorado	--	583	3,520	849	25,800	30,800
Connecticut	2	354	1,320	879	4,280	6,840
Delaware	--	--	--	--	352	352
Florida	20	353	5,430	18	6,320	12,100
Georgia	--	468	6,390	8,160	5,140	20,200
Hawaii	--	5	--	28	259	292
Idaho	--	489	78	1,120	13,000	14,700
Illinois	62	1,100	22,100	40,800	14,900	79,000
Indiana	6	796	13,300	45,400	29,900	89,400
Iowa	--	1,760	2,740	920	10,800	16,200
Kansas	--	1,430	2,990	4,700	14,300	23,400
Kentucky	1,940	3,120	36,200	163,000	189,000	393,000
Louisiana	139	323	614	1,670	891	3,630
Maine	--	131	176	212	--	518
Maryland 2/	--	296	330	784	2,120	3,530
Massachusetts	--	573	1,470	1,230	4,500	7,770
Michigan	57	135	2,650	2,700	18,600	24,200
Minnesota	--	203	20,500	1,920	33,200	55,900
Mississippi	--	163	5	64	--	232
Missouri	15	2,860	9,690	13,800	17,500	43,900
Montana	--	1,890	5,860	2,430	53,900	64,100
Nebraska	--	100	17	123	2,480	2,720
Nevada	--	1,100	21,500	7,820	129,000	159,000
New Hampshire	--	439	1,970	749	--	3,160
New Jersey	--	193	1,580	1,420	2,770	5,960
New Mexico	--	634	3,020	859	62,300	66,800
New York	--	530	3,250	1,960	3,800	9,540
North Carolina	--	978	5,980	4,900	11,700	23,500
North Dakota	--	42	838	--	2,960	3,840
Ohio	21	1,030	8,950	11,000	54,400	75,400
Oklahoma	2	248	3,540	4,820	9,100	17,700
Oregon	--	572	260	2,010	5,810	8,650
Pennsylvania	293	2,350	16,500	26,900	60,100	106,000
Rhode Island	--	22	20	47	--	89
South Carolina	--	108	3,360	1,410	--	4,870
South Dakota	--	22	757	3,970	2,130	6,880
Tennessee	37	1,250	7,470	6,280	15,300	30,400
Texas	8	618	5,520	13,400	14,900	34,400
Utah	39	360	1,210	50	21,900	23,600
Vermont	--	78	28	44	--	150
Virginia	707	1,200	20,800	19,100	117,000	159,000
Washington	--	889	1,370	9,270	19,500	31,000
West Virginia	201	1,280	24,500	36,400	134,000	197,000
Wisconsin	--	645	4,390	4,500	2,320	11,900
Wyoming	12	436	23,400	3,890	132,000	160,000
Total	3,730	35,500	328,000	463,000	1,490,000	2,320,000

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes District of Columbia.

FIGURE 1
SUPPLY TREND FOR U.S. INDUSTRIAL EXPLOSIVES

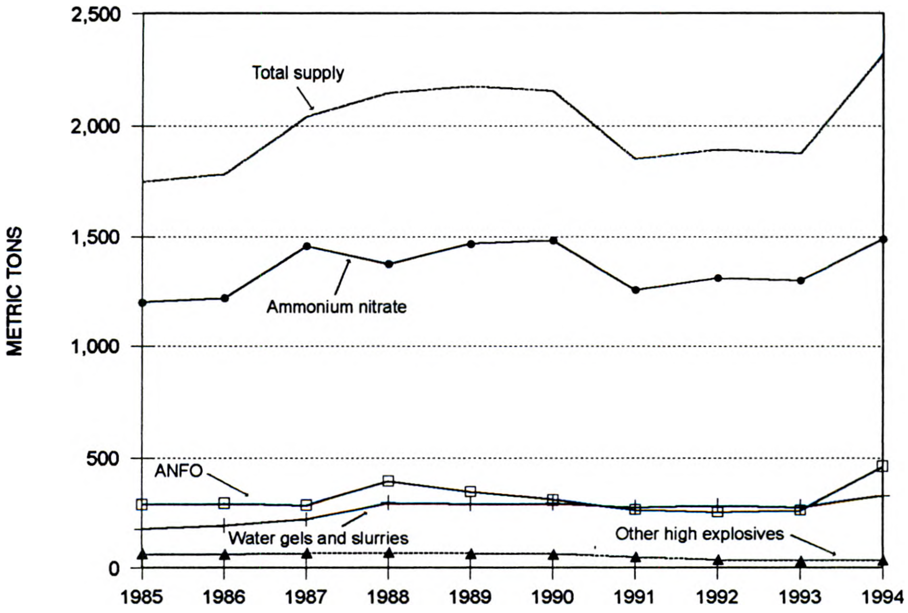
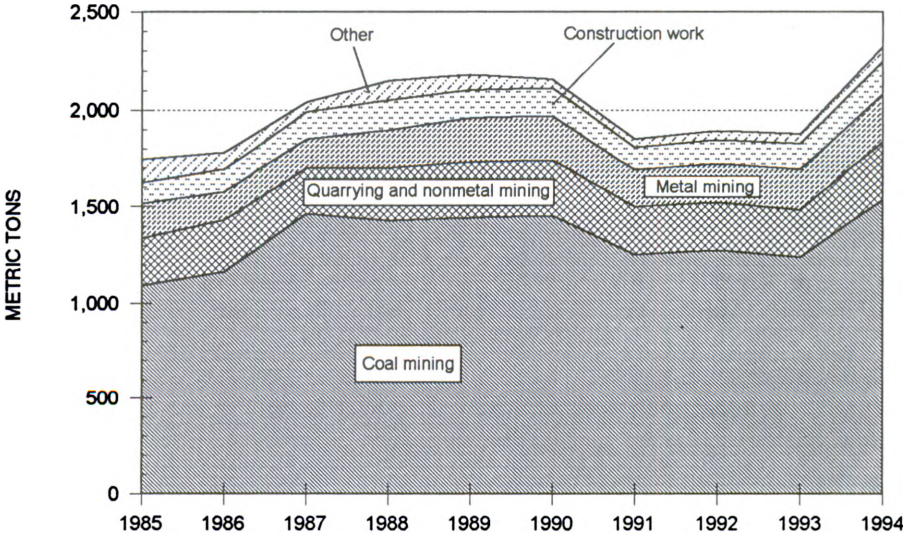


FIGURE 2
DEMAND TREND FOR U.S. INDUSTRIAL EXPLOSIVES



FELDSPAR AND NEPHELINE SYENITE

By Michael J. Potter

Feldspars are an aluminum silicate mineral group and occur widely in the earth's crust. The two largest end uses for processed feldspar are glass and ceramics. In glassmaking, feldspar provides alumina, which improves hardness, durability, and resistance of glass to chemical corrosion. In the ceramic industry, feldspar is used in ceramic bodies and glazes. As a flux, the mineral lowers the vitrifying temperature of a ceramic body during firing and forms a glassy phase in the body.[1]

Production

U.S. production of marketable feldspar (including aplite) in 1994 was 765,000 metric tons (mt) with a value of $31.2 million, according to the U.S. Bureau of Mines (USBM). Feldspar was mined in seven States, led by North Carolina, and followed, in descending order, by Virginia, Oklahoma, Georgia, California, Idaho, and South Dakota. North Carolina accounted for about 65% of the total. Ten U.S. companies operated 11 beneficiating plants and 1 grinding plant. North Carolina had five operations; the other six States listed above each had one. The grinding plant was in South Carolina.

Domestic production data for feldspar were developed by the USBM by means of a voluntary survey. Of the 11 active beneficiation plants, data were obtained from 8 by the close-out date, representing 73% of the total plants canvassed. The eight respondents reported a production of about 640,000 mt or 84% of the total domestic production shown in table 1. The estimated production of the nonrespondents, about 125,000 mt, was derived from past years' production levels and trends.

The Feldspar Corp. continued with its program to increase capacity for all products at its Spruce Pine, NC, operation. Franklin Industrial Minerals Co. of Nashville, TN, acquired 100% of KMG Minerals Inc., the largest U.S. producer of dry ground mica. KMG is also a producer of floated silica and potash feldspar. Franklin, a division of Franklin Industries Inc., merged its existing mica operations in Verlarde, NM, with KMG to form the KMG Minerals Div.[2]

Consumption

Sixty-three percent of feldspar (including aplite) sold or used in the United States went into glass, including glass containers and glass fiber. Feldspar going into pottery and other uses was 37% of the output.

World Review

Capacity.—The data in table 8 are rated capacity as of December 31, 1994. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgement of the author, can be brought into production within a short period of time with minimum capital expenditure. Because actual capacity data were not available, recent peak production during the past 5 years for the United States and foreign countries was considered to be equal to rated capacity.

In Australia, Minerals Corp. Ltd. commissioned a processing plant at Broken Hill, NSW. Feldspar reserves were put in excess of 2 million mt. Products included soda spar, potash spar, mixed soda-potash spar and aplite. Exports of ceramic grade feldspar to southeast Asia were anticipated in 1995.[3]

In Greece, quartz and feldspar producer Mevior SA was purchased by Dr. Eng. G. Georgiades for about $1.6 million. The processing plant, 26 kilometers north of Thessaloniki, was producing 16,000 mt per year of feldspar and 5,000 mt per year of quartz. Feldspar sales were equally divided between the domestic ceramic market and the Italian tile industry.[4]

In Malaysia, Commercial Minerals (Malaysia) Sdn Bhd, a subsidiary of Australia-based Commercial Minerals Ltd., started production of glass-grade potash feldspar at its plant at Pasir Gudang. Raw material for the operation was being supplied by Commercial's Pippingarra potash feldspar mine in northwest Australia.[5]

In the United Kingdom, Appleby Calumite Ltd. completely rebuilt its plant to process blast furnace slag, a byproduct from ironmaking, into Calumite. Calumite is basically lime, silica, and alumina in a vitreous form. Since it is already in a glassy phase and fuses easily, it results in fuel and energy savings in a glass batch. In 1994, over 60,000 mt of Calumite was sold, with 10,000 mt being exported. In the United Kingdom, glass containers were the largest user.[6]

Outlook

Glass containers have been the largest end use of feldspar in the United States. Shipments of glass containers in 1995 may be down about 3% after a slight decrease in 1994.[7] Glass bottles continue to face competition from plastic, metal, and paper containers. Recycled glass (cullet) is an ongoing part of the raw material consumed in glassmaking. Total housing starts in 1995 may be about the same as in 1994 (1.4 million). Housing starts in 1994 were about 9% higher than in 1993, resulting in demand for plumbing fixtures, glass fiber insulation, and tile. Residential remodeling was projected to show an increase of around 5% in 1994 and 1995.[8]

Nepheline Syenite

In Canada, nepheline syenite was produced by Unimin Canada Ltd. at Blue Mountain near Peterborough, Ontario. End uses included container glass, glass fiber insulation, ceramic whiteware, wall and floor tile, and as a filler-extender in paints, plastics, and foam rubber.

More than 75% of Canadian nepheline syenite output typically has been exported to the United States.[9]

Prices for Canadian nepheline syenite at yearend 1994 were approximately $21 per mt to $23 per mt, glass grade, 30 mesh, bulk, car lots/truck lots, depending on iron content; and $67 per mt for ceramic grade, 200 mesh, bagged, 1-ton lots.[10]

In Norway, North Cape Nefelin A/S changed its name to North Cape Minerals AS. The company produced nepheline syenite at an underground mining operation on the arctic island of Stjernøya. About 80% of the output was used for glass and about 15% went into ceramic applications. More than 90% of the production was exported to Western Europe.[11]

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[1] Kauffman, R.A. and D. Van Dyk. Feldspars. Ch. in Industrial Minerals and Rocks, 6th ed., 1994, p. 478.

[2] Industrial Minerals (London). World of Minerals. No. 326, Nov. 1994, p. 14.

[3] ———. No. 322, July 1994, p. 8.

[4] ———. No. 321, June 1994, p. 12.

[5] ———. p. 15.

[6] Glass. Iron Makers' Waste is Glass Makers' Gain. V. 71, No. 12, Dec. 1994, p. 466.

[7] Ceramic Industry. Business Outlook. V. 143, No. 7, Dec. 1994, p. 15.

[8] ———. Economic Forecast 1994-95. V. 143, No. 3, Aug. 1994, pp. 38-39.

[9] Guillet, G. R. Nepheline Syenite. Ch. in Industrial Minerals and Rocks, 6th ed., 1994, p. 719.

[10] Industrial Minerals (London). Prices. No. 327, Dec. 1994, p. 63.

[11] Work cited in footnote 9.

TABLE 1
SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS 1/

		1990	1991	1992	1993	1994
United States:						
Feldspar:						
Produced 2/	metric tons	630,000	580,000	725,000	770,000	765,000
Value	thousands	$28,500	$26,000	$28,500	$31,400	$31,200
Exports	metric tons	24,800	8,430	17,700	17,700	17,300
Value	thousands	$2,170	$1,330	$2,210	$1,840	$1,940
Imports for consumption	metric tons	11,300	17,900	13,000	7,050	7,360
Value	thousands	$723	$1,120	$923	$514	$513
Nepheline syenite:						
Imports for consumption	metric tons	276,000	289,000	335,000	289,000	333,000
Value	thousands	$12,200	$13,100	$14,700	$15,400	$18,700
Consumption, apparent 3/ (feldspar plus nepheline syenite)	thousand metric tons	893	878	1,060	1,050	1,088
World: Production (feldspar)	do.	5,990 r/	5,700 r/	6,090 r/	6,390 r/	6,250 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-silica mixtures and aplite; includes potash feldspar (8% K2O or higher).

3/ Production plus imports minus exports.

TABLE 2
FELDSPAR PRODUCED IN THE UNITED STATES 1/

(Thousand metric tons and thousand dollars)

Year	Flotation concentrate		Other 2/		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1993	366	15,600 r/	407	15,800	770	31,400
1994	384	16,400	381	14,800	765	31,200

r/ Revised.

1/ Previously published and 1994 data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes hand-cobbed, feldspar-silica mixtures (feldspar content), and aplite.

TABLE 3
PRODUCERS OF FELDSPAR AND FELDSPATHIC MATERIALS IN 1994

Company	Plant location	Product
APAC Arkansas Inc.	Muskogee, OK	Feldspar-silica mixture.
Corona Industrial Sand Co.	Corona, CA	Do.
The Feldspar Corp.	Monticello, GA	Potash feldspar.
Do.	Spruce Pine, NC	Soda-potash feldspar.
FMC Lithium Div.	Bessemer City, NC	Feldspar-silica mixture.
KMG Minerals, Inc.	Kings Mountain, NC	Potash feldspar.
KT Feldspar Corp.	Spruce Pine, NC	Soda-potash feldspar.
Pacer Corp.	Custer, SD	Potash feldspar.
Spartan Minerals Corp.	Pacolet, SC	Feldspar-silica mixture.
Unimin Corp.	Emmett, ID	Do.
Do.	Spruce Pine, NC	Soda-potash feldspar.
U.S. Silica	Montpelier, VA	Aplite.

TABLE 4
FELDSPAR 1/ 2/ SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE

(Thousand metric tons and thousand dollars)

	1993		1994	
Use	Quantity	Value	Quantity	Value
Flotation concentrate:				
Glass	138	6,650	128	6,430
Pottery	238	14,600	243	14,900
Total	376	21,200	371	21,300
Other 3/				
Glass	366	17,200	341	16,800
Pottery	W	W	W	W
Miscellaneous	W	W	W	W
Total	394	19,990	379	20,000
Total:				
Glass 4/	504	23,900	469	23,200
Pottery	W	W	W	W
Miscellaneous	W	W	W	W
Total	770	41,100	750	41,300

W Withheld to avoid disclosing company proprietary data; included in " Total."

1/ Includes potash feldspar (8% K2O or higher).

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes hand-cobbed, feldspar-silica mixtures (feldspar content), and aplite.

4/ Includes container glass and glass fiber.

TABLE 5
PRICES FOR FELDSPAR

(Dollars per metric ton, f.o.b. plant, bulk)

Producing States	1994
Ceramic grade:	
Monticello, GA, 200 mesh, potash	105
Spruce Pine, NC, 170 to 250 mesh, soda	66-68
Glass grade:	
Monticello, GA, 80 mesh, potash	88
Spruce Pine, NC, 30 mesh, soda	46

Source: Industrial Minerals (London), No. 327, Dec. 1994, p. 62.

TABLE 6
U.S. EXPORTS OF FELDSPAR, BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value	Quantity (metric tons)	Value
Canada	1,540	$172,000	1,630	$203,000
Dominican Republic	505	47,700	--	--
Guatemala	498	41,300	--	--
Italy	2,040	397,000	510	108,000
Mexico	5,990	330,000	11,800	973,000
Taiwan	5,370	589,000	1,810	239,000
Thailand	--	--	654	138,000
Venezuela	953	68,000	--	--
Other	791	190,000	888	275,000
Total	17,700	1,840,000	17,300	1,940,000

1/ Previously published and 1994 data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF FELDSPAR, BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value 2/	Quantity (metric tons)	Value 2/
Mexico	6,940	$468,000	7,210	$468,000
Other	118	46,100	141	45,700
Total	7,050	514,000	7,360	513,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Customs value.

Source: Bureau of the Census.

TABLE 8
WORLD FELDSPAR ANNUAL PRODUCTION CAPACITY, DECEMBER 31,1994

(Thousand metric tons)

	Rated capacity 1/
North America:	
Mexico	163
United States	770
Total	933
South America:	
Brazil	145
Colombia	78
Venezuela	230
Other	95
Total	548
Europe:	
Finland	53
France e/	420
Germany e/	410
Italy	1,690
Norway e/	100
Poland e/	138
Portugal e/	45
Romania	88
Russia e/	100
Spain	239
Uzbekistan e/	80
Other	86
Total	3,460
Africa:	
South Africa, Republic of	70
Other	46
Total	116
Asia and Oceania:	
India	68
Iran	65
Japan	89
Korea, Republic of	539
Thailand	703
Turkey	520
Other e/	82
Total	2,070
World total	7,120

e/ Estimated.

1/ Includes capacities of operating plants as well as plants on standby basis.

2/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 9
FELDSPAR: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina	28,000 r/	42,300 r/	48,500 r/	55,800 r/	50,000
Australia e/	16,000	16,000	15,000	15,000	16,000
Austria	8,790	10,400	11,100	8,490 r/	8,500
Brazil	105,000	119,000	140,000	145,000 r/	145,000
Burma 4/	2,560 r/	3,740 r/	1,620 r/	6,290 r/	4,000
Chile	2,980	4,010	5,740	4,150 r/	4,150
Colombia	34,800	45,600	78,400 r/	60,500 r/	70,000
Ecuador	8,130	5,010	3,250	3,300 e/	3,000
Egypt	9,890	32,600	32,000 e/	38,900 r/ e/	38,000
Finland	52,600	53,000	47,500	51,500 r/	51,500
France e/	420,000	400,000	282,000	274,000 r/	300,000
Germany:					
Eastern states (sand, including stone)	80,000 e/	XX	XX	XX	XX
Western states	338,000	XX	XX	XX	XX
Total e/	418,000	404,000	385,000	360,000 r/	350,000
Guatemala	11,900	6,960	8,050	7,500 e/	7,600
Hong Kong	3,820	--	--	--	--
India	54,100	65,100	67,700 r/	66,400 r/	67,000
Iran	32,100	64,800	52,100	25,000 r/	30,000
Italy	1,610,000	1,300,000	1,690,000	1,600,000 e/	1,600,000
Japan 5/	57,900	88,500	72,300 r/	71,600 r/	53,000
Kenya e/	1,290 6/	1,200	1,200	1,200	1,200
Korea, Republic of	237,000	248,000	282,000	539,000 r/	500,000
Macedonia e/	XX	XX	20,000	15,000	15,000
Mexico	163,000	152,000	160,000 r/	124,000 r/	130,000
Morocco e/	1,000	1,000	1,000	1,000	1,000
Nigeria e/	714 6/	700	700	700	700
Norway e/ 7/	90,000	90,000	100,000	100,000	100,000
Pakistan	10,200	10,200	19,200	17,000	17,000
Peru	10,000	3,000	10,000	10,000 e/	10,000
Philippines	168,000 r/	48,000	45,000 e/	24,200 r/	30,000
Poland	32,000 r/	138,000 r/	34,000 r/	35,000 r/ e/	35,000
Portugal e/	44,000 6/	45,000	40,000	45,000	45,000
Romania	45,000 e/	40,000 e/	27,700	87,700 r/	45,000
Russia e/	XX	XX	100,000	70,000	55,000
Serbia and Montenegro	XX	XX	5,110	2,680 r/	2,800
South Africa, Republic of	56,100	70,300	49,400	56,800 r/	47,200 6/
Spain 8/	214,000	192,000	204,000	239,000 r/	200,000
Sri Lanka	9,700	9,910	7,520	8,000 e/	8,100
Sweden	41,200	32,900	34,600 r/	30,000	30,000
Taiwan	7,320	1,340	2,220	2,100 r/	800
Thailand	311,000	703,000	560,000	601,000 r/	600,000
Turkey	182,000	230,000	465,000	520,000 r/	500,000
U.S.S.R. e/ 9/	300,000	250,000	XX	XX	XX
United Kingdom (china stone)	6,260	6,420	8,240 r/	6,570 r/	7,000
United States	630,000	580,000	725,000	770,000	765,000 6/

See footnotes at end of table.

TABLE 9--Continued
FELDSPAR: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Uruguay e/	3,000	3,000	3,000	3,000	3,000
Uzbekistan e/	XX	XX	80,000	70,000	70,000
Venezuela	91,000	138,000	169,000	220,000 r/	230,000
Yugoslavia 10/	43,500	40,000	XX	XX	XX
Zambia	60	70 e/	113	100 e/	100
Zimbabwe	2,200	3,820	2,700	1,550 r/	2,000
Total	5,990,000 r/	5,700,000 r/	6,090,000 r/	6,390,000 r/	5,480,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through Apr. 25, 1995.

3/ In addition to the countries listed, former Czechoslovakia, Madagascar, and Namibia produce feldspar, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.

4/ Data are for fiscal years beginning Apr. 1 of that stated.

5/ In addition, the following quantities of aplite ore were produced in metric tons: 1990--523,000; 1991--500,000; 1992--416,000; 1993--404,000 (revised); and 1994--385,000 (estimated).

6/ Reported figure.

7/ Excludes nepheline syenite.

8/ Includes pegmatite.

9/ Dissolved in Dec. 1991; however, information for 1992-94 is inadequate to formulate reliable estimates for individual countries other than those listed in this table.

10/ Dissolved in Apr. 1992.

TABLE 10
U.S. IMPORTS 1/ 2/ FOR CONSUMPTION OF NEPHELINE SYENITE

Year	Quantity (metric tons)	Value 3/ (thousands)
1993	289,000	$15,400
1994	333,000	18,700

1/ Crude and ground combined.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

3/ Customs value.

Source: Bureau of the Census.

FLUORSPAR

By M. Michael Miller

Traditionally, fluorspar has been considered vital to the Nation for both national security and economic reasons. It is used directly or indirectly to manufacture products such as aluminum, gasoline, insulating foams, refrigerants, steel, and uranium fuel. Most fluorspar consumption and trade involves either acid grade, which is greater than 97% calcium fluoride or metallurgical grade, which is 97% or less calcium fluoride.

In the United States, one producer supplied about 10% of the Nation's fluorspar requirements, calculated as a percentage of apparent consumption. This included fluorspar processed from mined ore and fluorspar processed from National Defense Stockpile material. Supplementing fluorspar as a domestic source of fluorine, but not included in fluorspar production or consumption calculations, was byproduct fluorosilicic acid production from some phosphoric acid producers. According to the Bureau of the Census and the U.S. Bureau of Mines (USBM), imports of fluorspar were essentially unchanged compared with the 1993 figures. Hydrofluoric acid (HF) imports were 8% higher than those reported in the previous year.

Legislation and Government Programs

The Defense Logistics Agency, Defense National Stockpile Center (DLA-DNSC), measures the fluorspar stockpile in standard dry tons (sdt). In 1994, it was authorized to sell 20,000 sdt (about 18,100 metric tons) of metallurgical grade and 300,000 sdt (about 272,000 metric tons) of acid grade during fiscal year 1994 (October 1, 1993 to September 30, 1994). During this period, the DLA-DNSC reported sales of 19,000 sdt (about 17,000 metric tons) of metallurgical grade from a stockpile in Large, PA, and 280,638 sdt (about 255,000 metric tons) of acid grade from stockpiles in Wilmington, DE. Cumulative sales of fluorspar from the Defense Stockpile, since the current disposal began in 1992 through 1994, are 36,265 sdt (about 32,900 metric tons) of metallurgical grade and 287,895 sdt (about 261,000 metric tons) of acid grade. According to the DLA-DNSC's fiscal year 1995 Annual Materials Plan, further sales of both metallurgical grade and acid grade were planned for fiscal year 1995.

The Environmental Protection Agency issued the final rule on its program for evaluating and regulating substitutes for ozone-depleting chemicals being phased out under the stratospheric ozone protection provisions of the Clean Air Act (CAA). In section 612 of the CAA, the agency is authorized to identify and restrict the use of substitutes for class I and class II ozone-depleting substances where it has determined that alternatives exist that reduce overall risk to human health and the environment. The program is called the Significant New Alternatives Policy (SNAP) program. The intended effect of this final rule is to expedite movement away from ozone-depleting compounds by identifying substitutes that offer lower overall risks to human health and the environment.[1] It is the acceptance of these new alternative compounds that will drive demand for fluorspar in the future.

The Division of Oral Health, Centers for Disease Control and Prevention, released an updated version of "Water Fluoridation - A Manual for Water Plant Operators." The manual provides technical information that will enable water plant operators to improve the operation and maintenance of their water fluoridation facilities. The fluoridation of public water supplies requires strict control of dosage rates for maximum dental health benefits. Accurate analytical determination of the fluoride level in the water is essential and is included in this manual. The manual covers the use of fluorosilicic acid, sodium fluoride, sodium fluorosilicate, and other fluoride chemicals.[2]

Production

Domestic production data for fluorspar were developed by the USBM from voluntary surveys of U.S. operations. Surveys were conducted to obtain fluorspar mine production and shipments and fluorosilicic acid production. Of the four fluorspar mining operations to which a survey request was sent, four responded, representing 100% of known domestic shipments. Actual production quantities and values in table 1 are withheld to protect company proprietary data, but an estimate of total shipments is provided. Of the 11 fluorosilicic acid operations surveyed, 9 respondents reported production, representing 100% of the quantity reported.

Illinois was the only State reporting mine production in 1994 and accounted for 100% of all reported U.S. shipments. Specific data on shipments of fluorspar by State and grade are withheld to avoid disclosing company proprietary data.

Ozark-Mahoning Co., the Nation's largest fluorspar producer and a subsidiary of Elf Atochem North America Inc., operated three mines and a flotation plant in Pope and Hardin Counties, IL. Ozark-Mahoning closed its Denton Mine in the third quarter of 1994, but made up lost mine production from its remaining two mines. It operated two shifts per day at its No. 1 Mine and one shift per day at its Annabell Lee Mine. It also processed some material from the National Defense Stockpile to supplement its production. Seaforth Mineral & Ore Co. Inc. dried imported fluorspar at its facilities at Cave-In-Rock, IL, and East Liverpool, OH, for sale primarily to consumers in the ceramics, glass, and steel industries. The company supplemented its supplies by purchasing 106,638 sdt (about 97,000 metric tons) of acidspar from the National Defense Stockpiles in Wilmington, DE.

Silverspar Minerals, Inc. invested money in the renovation and upgrade of the former Babb-Barnes flotation mill near Salem, KY. Mill feed will initially be supplied by material purchased from the National Defense Stockpile. The mill was scheduled to be up and running by the middle of 1995.[3] The original mill was built in the early 1970's and was last operated in 1978 by Frontier Spar Corp., a wholly owned subsidiary of Marathon Oil Co.

Four companies operating nine plants processing phosphate rock for the production of phosphoric acid sold a reported 54,900 tons of byproduct fluorosilicic acid at a value of about $6.58 million. This was equal to 96,700 tons of 92% fluorspar equivalent. Since fluorosilicic acid is a byproduct of the fertilizer industry and is not manufactured for itself alone, shortages may occur when fertilizer production goes down.

Consumption

Domestic consumption data for fluorspar were developed by the USBM from voluntary surveys of U.S. operations. The consumption survey was sent to 72 operations quarterly and to 4 additional operations annually. Of the operations surveyed quarterly, 90% responded. Of the operations surveyed on an annual basis, 100% responded. *(See table 1.)*

Acid-grade fluorspar, containing greater than 97% calcium fluoride (CaF_2), was used primarily as a feedstock in the manufacture of HF and to produce aluminum fluoride. Ceramic-grade fluorspar, containing 85% to 95% CaF_2, was used for the production of glass and enamel, to make welding rod coatings, and as a flux in the steel industry. Metallurgical-grade fluorspar, containing 60% to 85% or more CaF_2, was used primarily as a fluxing agent by the steel industry. Fluorspar is added to the slag to make it more reactive. It increases the fluidity of the slag (by reducing its melting point) and thus increases the chemical reactivity of the slag. Reducing the melting point of the slag brings lime and other fluxes into solution to allow the absorption of impurities.

Reported domestic consumption by the HF industry in 1994 increased by 11%. Reported consumption by the steel industry in basic oxygen and electric arc furnaces decreased by about 7% in 1994, although U.S. raw steel production in 1994 increased by about 3% compared with 1993.

In the ceramic industry, fluorspar was used as a flux and as an opacifier in the production of flint glass, white or opal glass, and enamels. Fluorspar was used in the manufacture of aluminum, brick, cement, and glass fibers, and was also used in the melt shop by the foundry industry.

Three companies reported fluorspar consumption for the production of HF. The largest use of HF, accounting for 60%-65% of HF withdrawn from the system, was for the production of a wide range of fluorocarbon chemicals, including fluoropolymers, chlorofluorocarbons (CFC's), hydrochlorofluorocarbons (HCFC's), and hydrofluorocarbons (HFC's). CFC's, HCFC's and HFC's were produced by seven companies: Allied-Signal Corp., Ausimont USA Inc., E. I. du Pont de Nemours & Company Inc., Elf Atochem North America Inc., I.C.I. Americas Inc., La Roche Chemicals Inc., and MDA Manufacturing Ltd. The latter is a joint venture between Daikin America Inc. and 3M Corp. producing HCFC-22 and hexafluoropropane for captive use in fluoropolymer manufacturing. According to preliminary data from the U.S. International Trade Commission, production of trichlorofluoromethane (CFC-11) decreased by 74% to 8,481 tons and chlorodifluoromethane (HCFC-22) increased by about 6% to 139,444 tons. The number of producers of dichlorodifluoromethane (CFC-12) decreased to the point where production figures had to be withheld. No information is currently collected on production of the HCFC and HFC replacement compounds.

Some of the replacements for CFC's will be HCFC's 22, 123, 124, 141b, and 142b. These HCFC substitutes have ozone-depletion potentials much lower than that of CFC-11, CFC-12, and CFC-113, which in total have accounted for more than 90% of CFC consumption. HCFC-22 has been used for home air conditioning for years, and HCFC-141b and HCFC-142b have replaced most of the CFC-11 and CFC-12 used in foam blowing. Unfortunately, because of the recently agreed upon phaseout schedule for HCFC's and the likelihood that the schedule will be accelerated, the market for HCFC's will exist for only a relatively short time. Industry expects HCFC's to be produced and utilized at least through the end of this decade.

The HFC replacements have no ozone-depletion potential because they contain no chlorine atoms. The most promising HFC candidate is HFC-134a, which is already replacing CFC-12 in auto air conditioners and is expected to replace CFC-12 in medium temperature range refrigeration systems. HFC's 32, 125, 143a, and 152a also are being produced domestically, but in much smaller quantities. These four HFC's hold potential for use by themselves or more likely as blends for specific uses, and some interim replacements may be mixtures of these compounds and HCFC's. HFC 227 is being evaluated for use in medical aerosols. HFC 245 and 356 are being tested as potential replacements for HCFC-141b in blowing agents for thermosets such as polyurethane.

The manufacture of aluminum fluoride for use in aluminum reduction cells was a major use of HF. In the Hall-Héroult process, alumina is dissolved in a bath of molten cryolite, aluminum fluoride, and fluorspar to allow electrolytic recovery of aluminum. About 20 kilograms of fluorides were consumed for each metric ton of aluminum produced in a prebaked aluminum smelter. Aluminum fluoride was used by the ceramic industry for some body and glaze mixtures and in the production of specialty refractory products. It was used in the manufacture of aluminum silicates and in the glass industry as a filler.

HF was consumed in the manufacture of uranium tetrafluoride that was used in the process of concentrating uranium isotope 235 for use as nuclear fuel and in fission explosives. It also was used in stainless steel pickling, petroleum alkylation, glass etching, and in oil and gas well treatment.

HF was used as a cleaner and etcher in the electronics industry. Allied-Signal Inc. announced it was combining technologies with Chemical Suppliers Inc. (CSI) to manufacture high-purity 49% HF for the electronics market. Plans called for the construction of a 1,630-ton-per-year (1,800-short-ton-per-year) high-purity HF plant at Allied-Signal's Geismar, LA, site. Startup was scheduled for the second quarter 1995. Allied-Signal would supply bulk quantities to electronic chemical suppliers and CSI would sell directly to semiconductor manufacturers. At present, electronic chemical suppliers purchase merchant-grade HF and process their own high-purity HF.[4]

HF was used as the feedstock in the manufacture of a host of fluorine chemicals used in dielectrics, metallurgy, wood preservatives, herbicides, mouthwashes, decay-preventing dentifrices, plastics, and water fluoridation.

Byproduct fluorosilicic acid was used in water fluoridation (56%), either directly or after processing to sodium silicofluoride, to make aluminum fluoride for the aluminum industry (28%), and in other uses (15%). *(See table 2.)*

Stocks

Consumer stocks at yearend were 49,400 tons, a decrease of 34% from the level reported in 1993. Consumer and distributor stocks contained an additional 251,000 tons purchased from the National Defense Stockpile. As a result of these sales, as of December 31, 1994, the National Defense Stockpile fluorspar inventory contained about 632,000 sdt (573,000 metric tons) of acid-grade material, about 263,000 sdt (239,000 metric tons) of metallurgical-grade material, about 900 sdt (816 metric tons) of nonstockpile, acid-grade material, and about 107,000 sdt (97,000 metric tons) of nonstockpile, metallurgical-grade material. The fluorspar stockpiles were at 22 sites across the country. Since the sale of the majority of the Wilmington, DE, stockpile, the largest acid-grade stockpiles are in Memphis, TN; North Gate, CO; and New Haven, IN. The largest metallurgical-grade and submetallurgical-grade stockpiles are in Large, PA; Warren, OH; New Haven, IN; and Pine Bluff, AR.

Prices

The following is a comparison of yearend 1994 prices published by Industrial Minerals (Metal Bulletin PLC) to yearend 1993 prices. No domestic price for fluorspar was available for 1994. Published yearend producer prices for Mexico were unchanged for both acid grade and metallurgical grade. South African prices for acid grade decreased. No specific f.o.b. China or c.i.f. Gulf of Mexico prices were available for Chinese fluorspar. According to Industrial Minerals, the average U.S. Gulf port price, dry basis, for acid grade increased in 1994. Due to the lag between when purchase prices are negotiated and when material is delivered, the average import values shown in table 1 do not reflect the significant changes that occurred in list prices during 1994. *(See table 3.)*

Yearend price quotations from the Chemical Marketing Reporter (CMR) were unchanged at $0.6875 per pound for anhydrous HF and were unchanged at $52.00 per 100 pounds for aqueous HF, 70%, in tanks. These quotations were equivalent to about $1.52 per kilogram for anhydrous HF and $114.64 per 100 kilograms for aqueous HF, 70%, in tanks. The CMR yearend price quotation for hydrofluosilicic acid (fluorosilicic acid), 23% basis, in tanks, Midwest and East Coast terminals, was unchanged at $165 per short ton (about $182 per metric ton).

Foreign Trade

According to the Bureau of the Census, U.S. exports of fluorspar increased by about 84%. All U.S. exports were believed to be reexports of material imported into the United States or exports of material purchased from the National Defense Stockpile. *(See table 4.)*

Problems occurred with import statistics for acid-grade fluorspar entering the Houston Customs District. The problems were caused by the Customs reporting requirements for a Foreign Trade Zone (FTZ) and reporting errors for the value of some imports. Fluorspar imported into a FTZ for the production of HF is not listed as an import for consumption. Merchandise classified as having "nonprivileged foreign status" imported into the United States from a FTZ is listed as an import. This is merchandise that has been manipulated or manufactured in the FTZ so as to effect a change in tariff classification, e.g., fluorspar manufactured into HF. During the period 1991-94, these problems affected import statistics on shipments from China, Kenya, Morocco, Namibia, and the Republic of South Africa. For the years where import data were missing, Bureau of the Census sources were supplemented by information supplied by industry or the reported HF imports were converted to fluorspar equivalent and added to the appropriate country totals. Revisions or USBM adjustments were made to import data for 1991-94, as shown in tables 1 and 5.

In 1994, imports for consumption of fluorspar were essentially unchanged when compared with those the previous year, according to Bureau of the Census and USBM data. China was once again the largest supplier of fluorspar to the United States, followed by, in descending order, the Republic of South Africa and Mexico. China accounted for nearly 61% of U.S. fluorspar imports. The average c.i.f. unit value, in dollars per metric ton, was $97.70 for acid grade and $74.90 for subacid grade. *(See table 5.)*

There is a 13.5% ad valorem tariff on subacid-grade fluorspar imports that applies to both most-favored nation (MFN) and non-MFN countries. The tariff on acid grade for MFN countries is $2.10 per long ton ($2.07 per metric ton) and for non-MFN countries $5.60 per long ton ($5.51 per metric ton).

Imports for consumption of HF increased by 8% to a quantity equivalent to approximately 102,000 tons of fluorspar. Imports of synthetic and natural cryolite decreased 18% to a quantity equivalent to approximately 5,340 tons of fluorspar. Imports of aluminum fluoride decreased by 40% to a quantity equivalent to approximately 35,600 tons of fluorspar. *(See tables 6, 7, and 8.)*

World Review

World fluorspar consumption and production continued to trend downward. In order of rank, China, Mexico, Mongolia, and the Republic of South Africa were the major producers. The international fluorspar industry experienced the continuing effects of major changes in the traditional markets of aluminum, fluorochemicals, and steel. *(See table 9.)*

Canada.—The Government of Newfoundland and Labrador accepted a proposal from Northern Resource Investments Ltd. (NRI) to attempt to reactivate fluorspar mining operations at St. Lawrence on the Burin Peninsula of Newfoundland. NRI planned to conduct engineering, marketing, and feasibility studies during 1995. If results are favorable, preparation for mine reactivation will begin in 1996, with full mine production expected by late 1996. No mineral rights or mining assets were granted, but NRI has the exclusive right to obtain mining leases and to purchase the mining assets up to April 1996, upon completion of a positive feasibility study.[5]

China.—The Chinese central Government installed an export license and quota system for fluorspar exports effective April 1, 1994. The China Chamber of Commerce for the Import and Export of Metals, Minerals, and Chemicals and the Ministry of Foreign Trade and Economic Cooperation control the new system.

Total export quotas were set and individual exporters were required to submit bids for an export license. The bids were as a fee per ton of fluorspar exported. In three rounds of bidding that covered exports for 1994 and 1995, the export license fees were reported as being $9 per ton, $16 per ton, and $20 per ton in successive rounds of bidding.[6]

In addition to the export license fee system, the central Government imposed, effective April 1, 1994, a mining fee on domestic- and foreign-owned mining operations, which amounts to 1.18% of the value of minerals mined from all mining enterprises. This fee is expected to be fixed at 1.18% for at least 1 or 2 years. Between 1996 and 2000, the Government plans to raise the fee to 5% to 7%, and then to about 10%.[7]

The new export license and quota system reduced the number of exporters, limited the total tonnage be exported, and required export license fees. These factors, plus inflation pressures in China, more direct competition between international buyers, and the mining fees led to dramatic price increases for Chinese fluorspar.

European Union.—On March 4, 1994, the Commission of the European Communities imposed a definitive antidumping duty on imports of fluorspar originating in China. The duty was imposed on imports of fluorspar presented in filter cake form or in powder form, containing more than 97% calcium fluoride falling within harmonized code 2529.22.0000 or containing less than 97% calcium fluoride falling within harmonized code 2529.21.0000, originating in China. The duty was equal to the difference between a minimum price of ECU 113.50 per ton (dry net weight) and the net free at Community frontier price before customs clearance.[8]

South Africa, Republic of.—The Buffalo Fluorspar Mine, owned by Transvaal Mining and Finance Company Ltd., a wholly owned subsidiary of General Mining Union Corporation (Gencor), and managed by Gencor's Samancor Group, closed in early 1994. The mine, near Naboomspruit in the Waterberg area of Transvaal, about 250 kilometers north of Johannesburg, began operations in 1948. Reasons given for the closure were a deteriorating business environment, reduced output, lower prices, and only 2 years of reserves.[9] Product inventories at the time of closure were about 50,000 tons, which were all to be sold in 1994.[10]

Thailand.—Thailand produced nearly 24,000 tons of metallurgical grade in 1994. In 1993, when production totaled 48,400 tons, all production came from Mae Hong Son and Lamphun in the Northern Region and Phetchaburi and Kanchanaburi in the Central Region. Acid-grade production, which had ceased in 1986, was restarted in 1991 and 1992. Krabi Fluorite Company, a joint venture with Dong-Il Trading Company Limited of South Korea, produced acid grade mainly for domestic use. Operations were shut down in August 1992, because of high operating costs and high silica content in the product.[11]

Current Research and Technology

Researchers at Hashimoto Chemical Corp. and Tohoku University in Japan have developed advanced process technology utilizing granular $CaCO_3$ to recover CaF_2 from spent fluoride chemicals from semiconductor manufacturing. The new process utilizes a multistage column reactor to treat dilute HF and buffered HF (NH_4F-HF-H_2O) producing a minimum 98% CaF_2, with a maximum 2% $CaCO_3$, and 0.1% SiO_2. The effluent contains 5 parts per million (ppm) F (as ion), 2 ppm CaF_2 maximum, and 100 ppm SiO_2. Currently, $Ca(OH)_2$, $Al_2(SO_4)_3$, and other chemical materials are used to treat spent fluoride chemicals and produce large amounts of waste sludge.[12]

Texaco Refining and Marketing Inc. and UOP developed and tested additive technology to reduce aerosol formation of HF used in petroleum alkylation. HF is used as a catalyst to produce alkylate, a paraffinic gasoline-blending component with high octane and low vapor pressure. HF released under certain conditions, (i.e., superheated and released under pressure) may lead to aerosol formation, which is a suspension of fine liquid particles in a vapor cloud. Aerosol formation adds greatly to the quantity of HF contained in the cloud and thus adds to the hazards posed to workers and the public. The Texaco-UOP technology is an internal, passive mitigation solution. If an HF loss occurs, aerosol formation is reduced by the additive in the acid. HF alkylation accounts for about 65% of total alkylate production worldwide, but safety concerns have put its future in doubt.[13]

Outlook

Consumption of acidspar by the chemical industry for the production of HF is the largest market for fluorspar. The largest use of HF is in the manufacture of fluorocarbons (CFC's, HCFC's, and HFC's). The fluorocarbon market accounts for about 65% of HF demand and is thus the driving force in HF demand. Forecasting the demand for fluorocarbons in the near future is extremely difficult owing to the uncertainty of when and to what extent consumers will switch over to HCFC and HFC replacements. HF demand for fluorocarbon production is expected to be flat in the near term and then edge upward. No significant growth is expected long term in the other smaller HF markets.

The aluminum industry consumes fluorine from different sources and in different forms. Cryolite is the most important fluoride needed in aluminum smelting, but aluminum fluoride makes up for cell losses of both cryolite and aluminum fluoride. Aluminum fluoride is manufactured from fluorspar, HF, or fluorosilicic acid. Despite forecasts for growth in world aluminum production, the outlook for aluminum fluoride consumption is negative in the long term. The aluminum industry is eliminating the older inefficient Söderberg smelting technology, introducing process improvements, and tightening raw material specifications. Replacing the Söderberg plants will account for the bulk of the fluoride savings. Most of these older plants are in China and the former Soviet Union, so they will see the biggest impact on aluminum fluoride and fluorspar consumption.[14]

Consumption of metallurgical-grade fluorspar by the U.S. steel industry decreased again in 1994. The decreasing level of consumption is mainly a result of continuing changes in technology, improvements in efficiencies, and tighter raw material specifications. These factors indicate that U.S. consumption of metallurgical grade by the steel industry will continue to decrease through the 1990's. Small, nonsteel markets should remain stable, but account for no more than 20,000 tons per year.

The international market for metallurgical grade is still huge. Worldwide, the steel industry is still the largest consumer of fluorspar. However, with the spread of more efficient steelmaking process, the unit consumption of fluorspar is expected to fall.

This will probably offset overall gains in steel production, primarily in developing countries.

After pronounced price increases in 1994, prices may begin to level off in the latter part of 1995. The rise in prices has been driven by developments in China, but at some point Chinese suppliers may find themselves losing market share to fluorspar producers in other countries now able to undercut the Chinese prices. The question will be is there enough alternative supply available from non-Chinese suppliers. North American customers may look to increased production in Mexico, the possible reactivation of Canada's St. Lawrence Fluorspar Co. in 1996, and possibly production from Silverspar Minerals' Salem, KY, flotation mill. The latter is supposed to receive mill feed purchased from the National Defense Stockpile and be on-line by the middle of 1995.

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TABLE 1
SALIENT FLUORSPAR STATISTICS 1/ 2/

		1990	1991	1992	1993	1994
United States:						
Production:						
Finished (shipments) e/	metric tons	63,500	58,000	51,000 3/	56,000 r/ 3/	49,000 3/
Value, f.o.b. mine	thousands	W	W	W	W	W
Exports 4/	metric tons	14,900	73,900	13,600	12,700	23,500
Value 5/	thousands	1,890	16,400	1,980	2,130	3,690
Imports 6/	metric tons	514,000	495,000	534,000	497,000	492,000
Value 7/	thousands	65,900 r/	59,200 r/	54,600 r/	47,000 r/	47,600
Value per ton, acid grade 7/		$135.37 r/	$124.27 r/	$106.71 r/	$97.60 r/	$97.66
Value per ton, metallurgical grade 7/		$101.55	$95.64	$84.72	$73.43	$74.88
Consumption (reported)	metric tons	565,000	484,000	485,000	447,000	486,000
Consumption (apparent) 8/	do.	567,000 r/	485,000 r/	569,000 r/	537,000 r/	543,000
Stocks, December 31:						
Consumer and distributor	do.	74,700	69,000	72,000	75,000	300,000 9/
Government stockpile	do.	1,180,000	1,180,000	1,180,000	1,160,000	909,000
Total (stocks):	do.	1,260,000	1,250,000	1,250,000	1,240,000	1,210,000
World: Production	do.	5,120,000 r/	4,210,000 r/	4,010,000 r/	3,930,000 r/	3,850,000 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Does not include fluorosilicic acid (H_2SiF_6) or imports of hydrofluoric acid (HF) and cryolite.

3/ Includes fluorspar from the National Defense Stockpile beneficiated by Ozark-Mahoning Co., IL.

4/ Source: U.S. Bureau of the Census.

5/ F.a.s. values at U.S. ports.

6/ Source: U.S. Bureau of the Census as modified by the U.S. Bureau of Mines.

7/ C.i.f. values at U.S. ports.

8/ U.S. primary and secondary production plus imports minus exports plus adjustments for Government and industry stock changes.

9/ Includes fluospar purchased from the National Defense Stockpile.

TABLE 2
U.S. (REPORTED) CONSUMPTION OF FLUORSPAR, BY END USE 1/

(Metric tons)

End use or product	1993	1994	1993	1994	1993	1994
	Containing more than 97% calcium fluoride (CaF_2)		Containing not more than 97% calcium fluoride (CaF_2)		Total	
Hydrofluoric acid (HF)	321,000	356,000	--	--	321,000	356,000
Basic oxygen furnaces	--	--	26,900	29,500	26,900	29,500
Electric furnaces	1,320	1,320	20,200	14,100	21,500	15,400
Iron and steel foundries	--	--	1,370	3,300	1,370	3,300
Other 2/	W	W	W	W	77,000	81,800
Total	W	W	W	W	447,000	486,000
Stocks (Consumer), December 31	73,000	48,900	2,400	497	75,000	49,400

W Withheld to avoid disclosing company proprietary data; included in "Other" and "Total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes aluminum fluoride, enamel, glass and fiberglass, primary aluminum, primary magnesium, and welding rod coatings.

TABLE 3
PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source-grade	1993	1994
Mexican, f.o.b., Tampico:		
Acidspar filtercake	100-110	100-112
Metallurgical grade	80 - 85	80 - 95
South African, acidspar dry basis, F.o.b. Durban	90 - 95	88-100
U.S. Gulf port, dry basis, acidspar.	95-100	120-130

Source: Industrial Minerals (Metal Bulletin PLC), No. 315, p. 54, Dec. 1993 and No. 327, p. 62, Dec. 1994.

TABLE 4
U.S. EXPORTS OF FLUORSPAR, BY COUNTRY 1/

Country	1993 Quantity (metric tons)	1993 Value 2/	1994 Quantity (metric tons)	1994 Value 2/
Australia	40	$7,950	189	$27,400
Canada	11,100	1,890,000	16,300	2,650,000
Colombia	57	8,350	339	58,700
Korea, Republic of	1,040	117,000	1,360	198,000
Mexico	212	23,700	2,900	296,000
Taiwan	--	--	1,930	371,000
Venezuela	290	71,700	276	64,100
Other 3/	27	3,950	185	28,900
Total	12,700	2,130,000	23,500	3,690,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ F.a.s. values at U.S. ports.

3/ Includes Argentina, Chile, Dominican Republic, and Peru data.

Source: Bureau of the Census.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF FLUORSPAR, BY COUNTRY AND CUSTOMS DISTRICT 1/

Country and customs district	1993 Quantity (metric tons)	1993 Value 2/ (thousands)	1994 Quantity (metric tons)	1994 Value 2/ (thousands)
CONTAINING MORE THAN 97% CALCIUM FLUORIDE (CaF_2)				
Canada: Detroit 3/	10,000	$600	3,610	$216
China:				
Houston 4/	146,000 r/	13,600 r/	153,000	14,600
New Orleans	150,000	13,300	129,000	11,900
Total	296,000 r/	26,900 r/	282,000	26,500
France:				
Cleveland	15	2	--	--
Philadelphia	18	8	18	9
Total	33	10	18	9
Kenya:				
Houston 4/	--	--	3,050	274
Mexico:				
Laredo	27,100	3,330	9,390	1,130
New Orleans	1,430	140	1,020	98
Total	28,500	3,470	10,400	1,220
Morocco:				
Houston	--	--	7,250	910
New Orleans	--	--	8,180	856
Total	--	--	15,400	1,770
South Africa, Republic of:				
New Orleans	99,600	11,400	119,000	12,400
Grand total	434,000 r/	42,300 r/	433,000	42,300
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE (CaF_2)				
China:				
Baltimore	--	--	4,040	299
New Orleans	36,400	$2,510	12,300	865
Total	36,400	2,510	16,300	1,160
Mexico:				
El Paso	3,380	235	4,250	335
Laredo	591	31	2,350	103
New Orleans	22,600	1,850	35,800	2,800
Total	26,600	2,120	42,400	3,240
Grand total	63,000	4,630	58,800	4,400

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ C.i.f. values at U.S. ports.

3/ Data supplied by importer.

4/ Data contain fluorspar equivalent, back-calculated from imported HF produced in La Porte, TX, Foreign Trade Zone.

Source: Bureau of the Census, adjusted by the U.S. Bureau of Mines.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION
OF HYDROFLUORIC ACID (HF), BY COUNTRY 1/

Country	1993 Quantity (metric tons)	1993 Value 2/ (thousands)	1994 Quantity (metric tons)	1994 Value 2/ (thousands)
Brazil	--	--	16	$16
Canada	141	$299	100	270
France	--	--	359	392
Germany	91	214	116	233
Japan	153	471	582	1,850
Mexico	62,200	58,500	67,000	60,200
Sweden	37	56	--	--
United Kingdom	366	402	38	39
Total	62,900	60,000	68,200	63,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ C.i.f. values at U.S. ports.

Source: Bureau of the Census, adjusted by the U.S. Bureau of Mines.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION
OF CRYOLITE, BY COUNTRY 1/

Country	1993 Quantity (metric tons)	1993 Value 2/ (thousands)	1994 Quantity (metric tons)	1994 Value 2/ (thousands)
Canada	551	$271	1,310	$415
China	291	208	117	84
Denmark	552	490	143	135
Germany	1,530	1,210	1,660	1,480
Italy	428	496	688	768
Hungary	119	96	48	40
Japan	232	228	311	395
Other 3/	76	66	170	136
Total	3,780	3,070	4,450	3,460

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ C.i.f. values at U.S. ports.
3/ Includes data for France, Mexico, Russia, and the Czech Republic.

Source: Bureau of the Census, adjusted by the U.S. Bureau of Mines.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION
OF ALUMINUM FLUORIDE, BY COUNTRY 1/

Country	1993 Quantity (metric tons)	1993 Value 2/ (thousands)	1994 Quantity (metric tons)	1994 Value 2/ (thousands)
Canada	5,390	$4,740	2,730	$1,740
China	1,650	1,250	21	14
Italy	2,660	2,170	1,990	7,770
Japan	6,470	5,560	17	37
Mexico	16,300	12,100	14,300	9,300
Norway	6,150	4,650	3,980	3,350
United Kingdom	450	254	429	261
Other	371 r/	296 r/	263	250
Total	39,400	31,100	23,700	22,700

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ C.i.f. values at U.S. ports.

Source: Bureau of the Census, adjusted by the U.S. Bureau of Mines.

TABLE 9
FLUORSPAR: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/ and grade 4/	1990	1991	1992	1993	1994 e/
Argentina	24,500 r/	16,500 r/	4,590 r/	4,610 r/	5,000
Brazil (marketable):					
Acid grade	47,700	52,400	61,400 r/	68,300 r/	65,000
Metallurgical grade	22,700	28,900	22,300 r/	24,600 r/	25,000
Total	70,400	81,300	83,700 r/	92,900 r/	90,000
Canada: Acid grade	21,400	--	--	--	--
China: e/					
Acid grade	700,000	700,000	700,000	800,000	800,000
Metallurgical grade	1,000,000	1,000,000	1,200,000	1,300,000	1,300,000
Total	1,700,000	1,700,000	1,900,000	2,100,000	2,100,000
Czech Republic	XX	XX	XX	22,100 r/	23,000
Czechoslovakia 5/	47,000	40,000 e/	40,000 e/	XX	XX
Egypt	1,250	1,790	1,700 e/	773 r/	700
France: e/					
Acid and ceramic grades	145,000	150,000	118,000 6/	100,000	100,000
Metallurgical grade	113,000	50,000	15,000 6/	25,000	25,000
Total	258,000 6/	200,000	133,000 6/	125,000	125,000
Germany:					
Eastern States	61,800	XX	XX	XX	XX
Western States (marketable)	85,300	XX	XX	XX	XX
Total	147,000	76,400 r/	53,100	40,000 r/	40,000
India:					
Acid grade	10,400	9,700	7,060 r/	7,800 r/	8,000
Metallurgical grade	13,000	14,400	13,600 r/	13,800 r/	14,000
Total	23,400	24,100	20,600 r/	21,600 r/	22,000
Iran 7/	4,770	12,300	9,180	10,000 e/	10,000
Italy:					
Acid grade	81,800	60,700	55,000 r/ e/	35,000 r/ e/	40,000
Metallurgical grade	40,700	37,900	25,000 e/	25,000 e/	--
Total	122,000	98,500	80,000 r/ e/	60,000 r/ e/	40,000
Kazakhstan e/	XX	XX	100,000	90,000	80,000
Kenya: Acid grade	112,000	77,400	80,600	78,700	64,000
Korea, North: Metallurgical grade e/	40,000	41,000	41,000	41,000	40,000
Korea, Republic of: Metallurgical grade	560	290	70	50 r/	50
Mexico: 8/					
Acid grade	428,000	277,000	189,000 r/	187,000 r/	221,000
Ceramic grade	11,000	--	--	--	--
Metallurgical grade	192,000	90,000	95,000 r/	93,000 r/	103,000
Submetallurgical grade e/	3,000	3,000	3,000	3,000	3,000
Total	634,000	370,000	287,000 r/ e/	283,000 r/ e/	327,000 6/
Mongolia:					
Acid grade	119,000	120,000	97,100 e/	80,000 e/	80,000
Other grades 9/	495,000	250,000	180,000 e/	100,000 e/	100,000
Total	614,000	370,000	277,000 e/	180,000 e/	180,000
Morocco: Acid grade	86,500	74,600	85,500	70,100 r/	85,000
Namibia: Acid grade 10/	27,100	34,600	37,200	43,500 r/	50,600 6/
Pakistan: Metallurgical grade e/	5,310 6/	5,300	5,000	5,100 r/	5,000
Romania: Metallurgical grade e/	12,000	12,000	15,000	15,000	15,000
Russia e/	XX	XX	100,000	70,000	60,000
South Africa, Republic of: 11/					
Acid grade e/	262,000	240,000	230,000	195,000	167,000 6/
Ceramic grade e/	7,500	6,000	5,500	3,800	--
Metallurgical grade e/	41,500	24,300	22,600	19,000	7,500 6/
Total	311,000	270,000	258,000	218,000	174,000 6/
Spain:					
Acid grade	144,000	107,000	91,000 r/	82,000 r/	90,000
Metallurgical grade e/	9,680 6/	5,000	5,000	5,000	5,000
Total e/	154,000 6/	112,000	96,000 r/	87,000 r/	95,000

See footnotes at end of table.

TABLE 9--Continued

FLUORSPAR: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/ and grade 4/	1990	1991	1992	1993	1994 e/
Thailand:					
Acid grade	--	1,450	4,860	--	--
Metallurgical grade	94,800	60,600	51,600	48,400 r/	24,000
Total	94,800	62,100	56,500	48,400 r/	24,000
Tunisia: Acid grade	41,000	37,600	13,800	--	--
Turkey: Metallurgical grade e/	10,000	5,000	3,070 6/	4,000 r/	4,000
U.S.S.R. e/ 12/	380,000	350,000	XX	XX	XX
United Kingdom	118,000	77,900	76,100 r/	70,300 r/	59,000
United States (shipments) e/	63,500	58,000	51,000	60,000	49,000
Uzbekistan e/	XX	XX	100,000	90,000	80,000
Grand total	5,120,000	4,210,000 r/	4,010,000 r/	3,930,000 r/	3,850,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 19, 1995.

3/ In addition to the countries listed, Bulgaria is believed to have produced fluorspar in the past, but production is not officially reported, and available information is inadequate for the formulation of reliable estimates of output levels.

4/ An effort has been made to subdivide production of all countries by grade (acid, ceramic, and metallurgical). Where this information is not available in official reports of the subject country, the data have been entered without qualifying notes.

5/ Dissolved Dec. 31, 1992.

6/ Reported figure.

7/ Year beginning Mar. 21 of that stated.

8/ Data are reported by Consejo de Recursos Minerales; but the production of submetallurgical grade and acid grade have been redistributed by the author based on industry data.

9/ Principally submetallurgical grade material.

10/ Data for 1993-94 are in wet tons.

11/ Data show estimated proportions of acid grade, ceramic grade, and metallurgical grade fluorspar within the reported totals.

12/ Dissolved in Dec. 1991.

GALLIUM

By Deborah A. Kramer

No gallium production was reported in the United States in 1994. The U.S. gallium demand was supplied primarily by imports. France, Russia, and Germany, in declining order, were the principal import sources, representing 83% of the total. Approximately 65% of the U.S. gallium demand was for optoelectronic devices [light-emitting diodes (LED's), laser diodes, photodetectors, and solar cells], and 33% was consumed for integrated circuits. The remainder was used in research and development and other applications. Gallium arsenide (GaAs) manufacturers are beginning to commercialize some of the products originally made for defense applications, and significant strides in the development of a brighter blue LED, based on gallium nitride (GaN) could expand the applications for gallium.

Production

No production of primary gallium was reported in 1994. Eagle-Picher Industries Inc. recovered and refined gallium from both domestic and imported sources at its plant in Quapaw, OK. Recapture Metals Inc., Blanding, UT, recovered gallium from scrap materials, predominantly scrap generated during the production of GaAs. Recapture Metals also upgraded gallium imported from Russia. *(See table 1.)*

Consumption

Gallium consumption increased significantly in 1994. Although the total quantity of gallium used in optoelectronic devices increased, its percentage of total consumption remained the same. The bulk of the increase in demand was in integrated circuits.

Night-vision goggle manufacturer ITT Corp. reportedly granted Bausch & Lomb exclusive marketing and distribution rights to sell the goggles into the sports market. This marketing effort is part of ITT's strategy to commercialize its military technology. ITT already markets night-vision goggles to the law enforcement and marine markets. To reduce costs for the products, ITT is trying to improve the manufacturing technique used to produce the GaAs microchannel plates that guide and amplify photons.[1]

McDonnell Douglas Corp. reportedly will transition its Improved Mast Mounted Sight Systems Processor, used primarily on the U.S. Army's OH-58D helicopter, to production status in mid-1996. The processor is based on GaAs integrated circuits and is one of the fastest programmable digital signal processors on the market, according to the company.[2] *(See tables 2 and 3.)*

Gallium data are collected from two voluntary surveys of U.S. operations. In 1994, there were 17 responses to the "Consumption of Gallium" survey, representing 68% of the total canvassed. Significant quantities of gallium are used by universities and Government research facilities, which are not canvassed by the Bureau's survey. Data in tables 1, 2, and 3 representing gallium consumption were adjusted to reflect full industry coverage.

Prices

Early in 1994, prices for gallium were reported to be about $130 to $170 per kilogram for 99.99%-pure to 99.9999%-pure gallium from China and Russia, and U.S. prices were about $300 per kilogram for high-grade gallium. Quoted yearend prices for gallium metal declined by $5 per kilogram for 99.9999%-pure and 99.99999%-pure material in 1994. Eagle-Picher reported that it had lowered prices because of competitive world pressure on prices and less costly raw materials. *(See table 4.)*

Foreign Trade

France, Russia, and Germany were the principal sources of imported gallium, accounting for 41%, 31%, and 11% of total imports, respectively. In addition to metallic gallium, the United States also imported significant quantities of GaAs wafers. In 1994, 1,190 undoped GaAs wafers were imported, primarily from Sweden (47%) and Japan (46%). Japan and Canada were the major sources of doped GaAs wafers, with 61% and 26%, respectively, of the total of 183,000 wafers. *(See table 5.)*

World Review

Crude gallium production was estimated to be about 51,000 kilograms in 1994. Principal world producers were Australia, Germany, and Russia. More than 15,000 kilograms of gallium were imported into Japan and the United States from Russia in 1994. Some of this material was thought to have been from stockpiles maintained in Russia. Rhône-Poulenc S.A. continued to feed its purification facility in France from stockpiled crude gallium produced earlier at its 50,000-kilogram-per-year plant in Australia and from gallium produced in Germany.

Germany.—In April, Rhône-Poulenc announced that it would acquire Ingal International Gallium GmbH. Ingal operated a gallium extraction plant in Stade and a gallium refining plant in Schwandorf. Rhône-Poulenc planned to close the Schwandorf plant, but continue to operate the Stade facility. Gallium refining operations would be moved to Rhône-Poulenc's current refining facility in Salindres, France.[3]

Japan.—Gallium imports into Japan in 1994 were estimated to be nearly 42 metric tons, about double the 1993 level. France supplied about one-half of the gallium imports, with a purity level of 99.9999% to 99.99999%. Russia, with 24% of the total imports, was the second largest source, but the purity level was only 99.99% and required further refining in Japan.[4] Demand for compound semiconductor materials in Japan continued to increase because of higher consumption of LED's for mobile telephones in Japan and for consumer electronics in China and other Asian countries. Total Japanese shipments for GaAs and gallium phosphide (GaP) in 1994 were ¥30 billion, and increase of 21% from 1993 shipments.[5] *(See table 6.)*

Current Research and Technology

Scientists at Harvard University reportedly fabricated a new type of transistor based on GaAs and a new insulator, gallium sulfide (GaS). This research is part of an effort to find an insulator for GaAs that essentially has the same properties that a silica insulator has for silicon. The Harvard group produced a new phase of GaS with a cubic structure that matches that of GaAs by decomposing $[(\text{tert-butyl})\text{GaS}]_4$ at 400° C and depositing the GaS by metal-organic chemical vapor deposition. A simple prototype GaAs device was created that performed better than a traditional GaAs field-effect transistor, but not as well as a silicon-base transistor. The research represents a first step in increasing the applications for GaAs devices.[6]

University and Government scientists continued to develop methods to improve the economics and technology of producing GaAs and other compound semiconducting materials. Researchers at Sandia National Laboratories developed a new optics-based monitoring system to control growth rates in molecular beam epitaxy (MBE). The technique has the potential to increase yields up to 50% by increasing accuracy and reproducibility.[7] At the National Institute of Standards, scientists were looking for commercial companies to license a laser photoionization technology that can simultaneously measure multiple substances being deposited during MBE.[8] Physicists at Nippon Telegraph & Telephone Corp. announced they had developed a method of controlling a semiconductor material so that it grows orderly rows of boxlike structures, called quantum dots. The quantum dots currently could be adapted as amplifiers for semiconductor lasers and could replace conventional etching techniques to produce a variety of minuscule electronic components.[9]

Brown University scientists were developing a method to grow GaN on silicon substrates by chemical vapor deposition and MBE. Aluminum gallium nitride, one of the compounds that could be produced by this method, would cover a spectral range for which there are few solid-state light sources. This compound, which emits blue light, would enable the development of full-color, solid-state displays when combined with existing red and green sources.[10]

The goal of a collaboration between Xerox, Honeywell Inc., and Sandia National Laboratories was to develop prototype indium gallium aluminum phosphide vertical cavity surface-emitting laser arrays that could operate at room temperature in a continuous mode. The 2-year project, funded for $3.1 million through the Advanced Projects Research Agency, would yield components that could become practical for low-cost networks based on plastic fiber and for the next generation of high-performance laser printers.[11]

AT&T Bell Laboratories announced the development of a new semiconductor laser design called a quantum cascade laser. The aluminum indium arsenide/gallium indium arsenide structure can be tailored to emit light at any frequency in the mid- to far-infrared range, which is not easily accessible with other laser diodes. In addition, the new structure is less temperature sensitive and produces an intrinsically narrower line width than conventional lasers. Potential applications for the new device are in chemical sensing applications and monitoring of gas emissions.[12]

Several organizations continued to develop LED's made principally from GaN that emit blue light. Japan's Nichia Chemical Industries Ltd. reported that it began commercial manufacture of a GaN LED that emits blue light at brightness of 1,000 millicandelas; most of the current blue LED's made from silicon carbide have a brightness of about 10 millicandelas.[13] At Boston University, researchers developed a new method for making GaN LED's that can be easily scaled up and uses MBE rather than metal organic chemical vapor deposition to produce the devices. Blue LED's are expected to be used for optical storage, color copiers, printers, and facsimile machines.[14]

Epitaxx Optoelectronic Devices Inc. reportedly produced an indium gallium arsenide detector array for use on an environmental research satellite mission. The detector array will be part of a focal plane array used to detect trace atmospheric gases. The satellite, sponsored by German and Dutch space agencies, is scheduled to be launched in 1998.[15]

Outlook

According to a study sponsored by Allied Business Intelligence, demand for military GaAs-base monolithic microwave integrated circuits is expected to grow at an annual rate of 9% over the next 5 years, in terms of dollar value. Electronic warfare devices, with 23% of the total, was the largest military use of these GaAs devices. Radar, 20%; communications equipment, 19%; navigation, 18%; and ordnance and weapons, 10% were the other military uses.[16]

Overall gallium demand should increase slightly as devices originally manufactured for military applications become commercialized. In addition, work to develop a blue LED based on GaN should expand the market for gallium throughout the world.

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[16] Military & Aerospace Electronics. Strong Growth Forecast in Military MMICs. V. 5, No. 13, Dec. 1994, p. 30.

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U.S. Bureau of Mines Publication

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Other Sources

Roskill Information Services Ltd. Gallium 1990, 5th ed.

TABLE 1
SALIENT U.S. GALLIUM STATISTICS 1/

(Kilograms unless otherwise specified)

	1990	1991	1992	1993	1994
Production e/	--	--	--	--	--
Imports for consumption	9,890	11,300	8,480	15,600	16,900
Consumption	9,860	11,200	10,600	11,300	15,500
Price per kilogram	$525	$525	$425	$400	$395

e/ Estimated.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

TABLE 2
U.S. CONSUMPTION OF GALLIUM 1/, BY END USE 2/

(Kilograms)

End use	1993	1994
Optoelectronic devices:		
Laser diodes and light-emitting diodes	6,470	9,240
Photodetectors and solar cells	890	840
Integrated circuits:		
Analog	2,420	2,760
Digital	325	2,370
Research and development	405	231
Other	834	115
Total	11,300	15,500

1/ Includes gallium metal and gallium compounds.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 3
STOCKS, RECEIPTS, AND CONSUMPTION OF GALLIUM 1/, BY GRADE 2/

(Kilograms)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
1993:				
97.0% to 99.9%	15	7	19	3
99.99% to 99.999%	11	106 r/	--	117 r/
99.9999%	397	6,270	6,360	308
99.99999% 3/	304	5,240 r/	4,970	568 r/
Total	727	11,600 r/	11,300	996 r/
1994:				
97.0% to 99.9%	3	--	1	2
99.99% to 99.999%	117	358	115	360
99.9999%	308	7,560	7,560	315
99.99999% 3/	568	7,770	7,870	459
Total	996	15,700	15,500	1,140

r/ Revised.

1/ Consumers only.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes 99.999999% -pure gallium.

TABLE 4
YEAREND GALLIUM PRICES

(Dollars per kilogram)

Gallium metal, 99.999999%-pure, 100-kilogram lots	$525
Gallium metal, 99.99999%-pure, 100-kilogram lots	395
Gallium metal, 99.9999%-pure, 100-kilogram lots	325
Gallium metal, 99.9999%-pure, imported	$380-425
Gallium oxide, 99.99%-pure, imported	275-350

Source: American Metal Market.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF GALLIUM 1/ (UNWROUGHT, WASTE AND SCRAP), BY COUNTRY

	1993		1994	
Country	Kilograms	Value	Kilograms	Value
France	5,630	$1,750,000	6,940	$1,960,000
Germany	4,190	1,150,000	1,830	428,000
Hungary	2,030	392,000	--	--
Kazakhstan	--	--	1,000	164,000
Russia	1,470	200,000	5,290	669,000
United Kingdom	434	83,300	634	51,500
Other	1,830	553,000	1,200	275,000
Total	15,600	4,130,000	16,900	3,550,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 6
WORLD ANNUAL PRIMARY GALLIUM PRODUCTION CAPACITY 1/, DECEMBER 31, 1994

(Metric tons)

North America: United States 2/	3
Europe:	
France	20
Germany	20
Hungary	4
Slovakia	3
Former U.S.S.R. e/	30
Total	77
Asia:	
China	8
Japan	7
Total	15
Oceania: Australia 2/	50
World total	145

e/ Estimated.

1/ Includes capacity at operating plants as well as at plants on standby basis.

2/ Standby capacity as of Dec. 31, 1994.

GARNET

By Gordon T. Austin

Technical-grade industrial garnet from the United States is a solid solution of almandite and pyrope that, when under pressure, breaks into sharp chisel-edged plates. Industry uses this garnet as an abrasive powder and to manufacture coated abrasives. Low-quality industrial garnet found uses primarily as airblasting or hydroblasting media and as filtration media.

Production.—In 1994, five U.S. firms produced 51,000 tons of crude garnet concentrate worth $6.1 million. The firms were Barton Mines Corp., Warren County, NY; NYCO Div. of Processed Minerals Inc., Essex County, NY; Patterson Materials Corp., Wingdale, NY; International Garnet Abrasive Inc., Clinton County, NY; and Emerald Creek Garnet Co., Benewah County, ID. All five firms were surveyed by the U.S. Bureau of Mines in its production of garnet (industrial) survey, a voluntary survey to determine U.S. production and sales of industrial garnet. Four of the five firms responded to the survey, the responding firms accounted for about 99% of the production of crude garnet concentrate.

Consumption and Uses.—In 1994, the quantity of garnet sold or used by producers was 40,600 tons valued at $15.1 million. *(See table 1.)*

The major industrial use for high-quality, high-value garnet since before 1880 has been as loose-grain abrasive for applications such as optical lens grinding and plate-glass grinding. In recent years, its applications included the high-quality, scratch-free lapping of semiconductor materials and other metals. The finishing of wood, leather, hard rubber, felt, and plastics often requires the use of garnet-coated abrasive papers and cloths.

The aluminum aircraft and shipbuilding industries in California and the Pacific Northwest use lower quality, lower cost alluvial garnet, primarily from Idaho, for sandblasting. Similar uses in the Eastern United States are for the cleaning and conditioning of aluminum and other soft metals and for cleaning of metal by structural steel fabrication shops. Mixed-media water filtration, using a mixture of sand, anthracite, and garnet, has displaced older filtration methods because it is more reliable and gives a better quality of water. Garnet also is used in hydrojet cutting; it is entrained in a high-pressure stream of water to cut many different materials. Demand for these uses has increased greatly. The manufacturers of nonskid floor paint also use alluvial and other low-cost garnets.

Garnet has obtained an intermediate place in the coated-abrasive field between low-cost quartz sand and more costly synthetic abrasives (silicon carbide and fused alumina). Garnet is reportedly more efficient based on unit production costs than quartz sand. It also produces a more desirable finish on items made of wood, leather, hard rubber, felt, and plastic.

Garnet, especially the lower grades, cannot compete with synthetic abrasives for most metalworking applications requiring substantial metal removal because of its friable nature and lower hardness.

Prices.—The average value per ton of crude garnet concentrates was $120. In 1994, the average value per ton of garnet sold or used was $372.

Foreign Trade.—Garnet exports, as reported to the USBM, by producers were about 10,000 tons. Export data on garnet were not available from the Bureau of the Census (Department of Commerce). Producers have reported export quantities to the USBM for the past 8 years.

Mineral brokers and other garnet importers reported to the USBM about 6,000 tons of imported garnet. Import data for garnet also were not available from the Bureau of the Census.

World Review.—The United States was the dominant world producer and consumer of garnet, accounting for approximately 45% of the estimated world output and nearly 40% of estimated world consumption. Studies are underway on two garnet deposits, an almandite deposit in Arizona and an andradite deposit in New Mexico.

Target Mines Ltd. (a subsidiary of the U.S. producer Barton Mines) continued to produce at near capacity from its Australian garnet sand operation.

The Chinese mines continued to increase production of garnet for the domestic and world market. Two mineral-sand mining operations in India continued to produce garnet as a byproduct of mineral sands production. Turkey and the Newly Independent States (formerly the U.S.S.R.) primarily produce for local markets.

Outlook

The U.S. production and consumption of industrial garnet during the next 5 years will be a function of the installed capacity and imports. Currently the industry is operating at or near capacity. If economics allow additional capacity to be added, production and consumption could increase to approximately 80,000 tons per year by 1999. If garnet were not available, other abrasives could be used in its place, but in many cases with some sacrifices in work volume, quality of work, or cost.

Substitution of other natural and synthetic material is present to some extent for all major end uses of garnet. Fused alumina and staurolite compete with garnet as a sandblasting material in the transportation equipment industries. Ilmenite and plastics compete as filtration media. Diamond, corundum, and fused alumina compete for lens grinding and for many lapping operations. Finally, sand, silicon carbide, and fused alumina compete for grinding and finishing of plastics, wood furniture, and other products.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Garnet Chapter of Mineral Commodity Summaries, 1995.

Abrasive Materials Annual Report, 1993.

Mineral Facts and Problems, 1985.

TABLE 1
SALIENT U.S. GARNET STATISTICS 1/

Year	Crude production		Sold or used	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1990	47,000	$6,940	45,900	$11,800
1991	50,900	7,530	48,100	13,000
1992	54,100	4,840	46,100	13,000
1993	44,000	4,440	55,800	15,400
1994	51,000	6,100	40,600	15,100

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

GEMSTONES

By Gordon T. Austin

Webster's dictionary defines a gem as "any jewel, whether stone, pearl or the like, having value and beauty that are intrinsic and not derived from its setting; a precious or, sometimes, a semiprecious stone cut and polished for ornament. A stone of value because it is carved or engraved, as a cameo or intaglio." Additionally, the dictionary states that gemstone or gem material is a stone or material from which a gem may be cut. So a gem, gemstone, or gem material may be described as inorganic or organic minerals used for personal adornment, display, or to manufacture objects of art because they possess beauty, rarity, and durability.

Production

In 1994, the value of natural gemstones produced from deposits in the United States was $50.5 million. Production of gemstones, in order of importance, included faceting rough, lapidary rough, carving material, specimen material, natural and cultured freshwater pearls, mother of pearl, saltwater pearls, shell, fossil ivory, amber, and coral.

In 1994, all 50 States produced at least $1,000 worth of gem materials. Ten States accounted for 93% of the total value of production of natural gemstones. The States, in order of declining value of production, were Tennessee, Arkansas, Alabama, Kentucky, Arizona, Montana, Oregon, California, and Utah. Certain States were known best for the production of a single gem material (i.e., Tennessee for freshwater pearls and Arkansas for quartz). Other States produced a variety of gemstones. Tennessee, Arkansas, Alabama, and Kentucky, in declining order of value of production, were the major producers of freshwater mussel shell and pearl. Arizona produced the greatest variety. Production included agate, amethyst, antlerite, azurite, chrysocolla, fire agate, garnets, jade, malachite, obsidian, onyx, peridot, petrified wood, precious opal, shattuchite, smithsonite, and turquoise. California, Idaho, Montana, and North Carolina also produced a variety of gemstones. Historically, North Carolina is the only State to have produced all four of the major gems: diamond, emerald, ruby, and sapphire. *(See table 1.)*

Laboratory grown synthetic gemstones have essentially the same appearance and optical, physical, and chemical properties as the natural material that they represent. Synthetic gemstones produced in the United States include alexandrite, coral, diamond, emerald, garnet, lapis lazuli, quartz, ruby, sapphire, spinel, and turquoise. Laboratory grown simulants have an appearance similar to that of a natural gem material but have different optical, physical, and chemical properties. The gemstone simulants produced in the United States include coral, cubic zirconia, lapis lazuli, malachite, and turquoise. Additionally, certain colors of synthetic sapphire and spinel, used to represent other gemstones, would be classed as simulants. Colored and colorless varieties of cubic zirconia are the major simulants produced. In 1994, the reported value of production of U.S. synthetic and simulant materials was $22.2 million. *(See table 2.)* Fourteen firms, four in California; four in Arizona; and one each in Michigan, New Jersey, New York, North Carolina, Ohio, and Washington, produced synthetic and simulant gem material. Production included the manufacture of alexandrite, amethyst, azurite/malachite, cubic zirconia, emerald, lapis, ruby, sapphire, and turquoise. The States in descending order of value of production were California, New York, New Jersey, Washington, Arizona, Michigan, New Mexico, and Ohio.

The U.S. Bureau of Mines estimates U.S. production from the "Natural and Synthetic Gem Material Survey," a voluntary survey of U.S. operations, and from Bureau estimates of unreported production. Of the 387 operations surveyed, 84% responded, 84% of the natural gemstone producers and 95% of the synthetic and simulant producers. The Bureau estimated the production by nonresponding operations, by professional collectors, and by amateur or hobbyist collectors. The basis for these estimates was information from published data, conversations with gem and mineral dealers, analyses of gem and mineral shows and sales statistics, and from information informally supplied by collectors.

The value of production by individual gemstone can be reported for those materials that have three or more producers and if one producer does not account for more than 75% of the total or if two do not account for 95% or more of the production. *(See table 3.)*

Consumption

Consumption of domestic gemstones was in the manufacture of jewelry, for exhibit in gem and mineral collections, for decorative purposes in statuettes, vases, and other art objects, and certain industrial applications.

Prices

Demand, beauty, durability, rarity, freedom from defects, and perfection of cutting decide the value of a gem. In establishing the price of gem diamond, the CSO's control over output and prices of diamond rough also is a major factor. *(See tables 4 and 5.)*

Foreign Trade

During 1994, the total value of all gemstones exported and reexported was about $2.24 billion, diamonds accounted for 87% of the total or $1.94 billion, while cut diamonds accounted for 78% of the total or $1.74 billion. The value of exports plus reexport of natural rough colored gemstones was about $29.5 million and the value of exports plus reexports of cut natural gemstones was about $198 million. Synthetic rough and cut exported plus reexports for the year were valued at $14.0 million and $12.9 million, respectively. Exported and reexported natural and cultured pearls were valued at $1.02 million and $6.13 million, respectively. During the year $34.4 million of coral and shell was exported and reexported.

The value of gems and gemstones imported increased 12% to a record high $6.44 billion. The value of imported gem diamonds accounted for about 89% of the total. *(See tables 6, 7, 8, 9, and 10.)*

World Review

Diamond sales by De Beers Centenary AG was $4.3 billion in 1994, a decrease of 2.7% compared with 1993 sales of $4.4 billion. Sales during the first half of 1994 were $2.6 billion, 4% more than the $2.5 billion for the first half of 1993, second half of 1994 sales were only $1.7 billion, 8% less than the $1.8 billion sales for the second half of 1993. De Beers controls about 80% of the rough, uncut diamonds sold in the world. During the past 5 years De Beers annual sales were: 1994, $4.25 billion; 1993, $4.40 billion; 1992, $3.42 billion; 1991, $3.93 billion; and 1990, $417 billion. During the same period De Beers' stocks of diamonds were: 1994, $4.38 billion; 1993, $4.10 billion; 1992, $3.36 billion; 1991, $3.03 billion; and 1990, $2.68 billion. During 1994 was the first time ever that De Beers' stock of diamonds were greater than its annual sales of diamonds. Sales of colored stones remained strong.

Natural diamond production occurs in Africa, Asia, Australia, and South America. The principal producing localities are as follows: in Africa—Angola, Botswana, Namibia, the Republic of South Africa, and Zaire; in Asia—Russia (northeastern Siberia and in the Yakutia); in Australia; and in South America—Venezuela and Brazil. *(See table 11.)*

Foreign countries in which major gemstone deposits (other than diamond) occur are Afghanistan (beryl, kunzite, ruby, tourmaline); Australia (beryl, opal, sapphire); Brazil (agate, amethyst, beryl, kunzite, ruby, sapphire, tourmaline, topaz); Burma (beryl, jade, ruby, sapphire, topaz); Colombia (beryl, sapphire); Kenya (beryl, garnet, sapphire); Madagascar (beryl, rose quartz, sapphire, tourmaline); Mexico (agate, opal, topaz); Sri Lanka (beryl, ruby, sapphire, topaz); Tanzania (tanzanite, garnet, ruby, sapphire, tourmaline); and Zambia (amethyst, beryl).

OUTLOOK

World demand for gem diamond can be expected to rise because of increasing effective personal incomes and the populations of the United States and other industrialized countries. Also demand will increase because of highly effective promotional efforts. These promotions are changing social customs in many eastern countries, particularly the use of diamond engagement rings. The changes are resulting in significant growth in the diamond market. Demand for other precious gems will continue to grow as diamonds become more expensive and the popularity and acceptance of colored gemstones increase. Demand for synthetic and simulant gemstones for both personal and industrial consumption is expected to increase. The diversity of sizes, types, uses, and values of gems and gemstones precludes any meaningful forecasting of future demand.

OTHER SOURCES OF INFORMATION

Bureau of Mines Publications

Gem Stones, Ch. in Mineral Commodity Summaries.

Mineral Facts and Problems, 1985.

Mineral Industry Surveys, Annual Advance Summary Supplement: Directory of Principal Gem Stone Producers in the United States, 1993.

Mineral Industry Surveys, Annual Advance Summary Supplement: An Overview of Gemstone Production in the United States.

TABLE 1
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size1/	Cost2/	Mohs	Specific gravity	Refraction	Refractive index	May be confused with-	Recognition characters
Amber	Hydrocarbon	Yellow, red, green, blue	Any	Low to medium	2.0-2.5	1.0-1.1	Single	1.54	Synthetic or pressed, plastics	Fossil resin, soft.
Beryl:										
Aquamarine	Beryllium aluminum silicate	Blue-green to light blue	Any	Medium to high	7.5-8.0	2.63-2.80	Double	1.58	Synthetic spinel, blue topaz	Double refraction, refractive index.
Bixbite	do.	do.	Small	Very high	7.5-8.0	2.63-2.80	do.	1.58	Pressed plastics, tourmaline	Refractive index.
Emerald	do.	Green	Medium	do.	7.5	2.63-2.80	do.	1.58	Fused emerald, glass, tourmaline, peridot, green garnet doublets	Emerald filter, dichroism, refractive index.
Emerald, synthetic	do.	do.	Small	High	7.5-8.0	2.63-2.80	do.	1.58	Genuine emerald	Flaws, brilliant, fluorescence in ultraviolent light.
Golden (heliodor)	do.	Yellow to golden	Any	Low to medium	7.5-8.0	2.63-2.80	do.	1.58	Citrine, topaz, glass, doublets	
Goshenite	do.	do.	Any	Low	7.5-8.0	2.63-2.80	do.	1.58	Quartz, glass, white sapphire, white topaz	Refractive index.
Morganite	do.	Pink to rose	Any	Low	7.5-8.0	2.63-2.80	do.	1.58	Kunzite, tourmaline, pink sapphire	Refractive index.
Calcite:										
Marble	Calcium carbonate	White, pink, red, blue, green, or brown	Any	Low	3.0	2.72	Double (strong)	1.49-1.66	Silicates, banded agate, alabaster gypsum	Translucent.
Mexican onyx	do.	do.	Any	Low	3.0	2.72	do.	1.6	do.	Banded, translucent.
Chrysoberyl:										
Alexandrite	Beryllium aluminate	Green by day, red by artificial light	Former U.S.S.R. (small), Sri Lanka (medium)	High	8.5	3.50-3.84	Double	1.75	Synthetic	Dichroism, inclusions in synthetic sapphire.
Catseye	do.	Greenish to brownish	Small to large	do.	8.5	3.50-3.84	do.	1.75	Synthetic, shell	Gravity and translucence.

See footnotes at end of table.

TABLE 1--Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size1/	Cost2/	Mohs	Specific gravity	Refraction	Refractive index	May be confused with-	Recognition characters
Chrysolte	do.	Yellow, green, and/or brown	Medium	Medium	8.5	3.50-3.84	do.	1.75	Tourmaline, peridot	Refractive index, silky.
Coral	Calcium carbonate	Orange, red, white, black, or green	Branching, medium	Low	3.5-4.0	2.6-2.7	do.	1.49-1.66	False coral	Dull translucent.
Corundum:										
Ruby	Aluminum oxide	Rose to deep purplish red	Small	Very high	9.0	3.95-4.10	do.	1.78	Synthetics, including spinel	Inclusions, fluorescence.
Sapphire	do.	Blue	Medium	High	9.0	3.95-4.10	do.	1.78	do.	Inclusions, double refraction, dichroism.
Sapphire, fancy	do.	Yellow, pink, white, orange, green, or violet	Medium to large	Medium	9.0	3.95-4.10	do.	1.78	Synthetics, glass and doublets	Inclusions, double refraction, refractive index.
Sapphire and ruby stars	do.	Red, pink, violet blue, or gray	do.	High to low	9.0	3.95-4.10	do.	1.78	Star quartz, synthetic stars	Shows asterism, color on side view.
Sapphire or ruby synthetic	do.	Yellow, pink, or blue	Up to 20 carats	Low	9.0	3.95-4.10	do.	1.78	Synthetic spinel, glass	Curved strae, bubble inclusions.
Diamond	Carbon	White, blue-white, yellow, brown, green, pink, blue	Any	Very high	10.0	3.516-3.525	Single	2.42	Zircon, titania, cubic zirconia	High index, dispersion, single refraction, hardness, cut, luster.
Feldspar:										
Amazonite	Alkali aluminum silicate	Green	Large	Low	6.0-6.5	2.56	--	1.52	Jade	Cleavage, sheen, vitreous to pearly, opaque, grid.
Labradorite	do.	Gray with blue and bronze sheen color play	do.	Low	6.0-6.5	2.56	--	1.56	do.	Cleavage, sheen, vitreous to pearly opaque, grid.
Moonstone	do.	White	do.	Low	6.0-6.5	2.77	--	1.52-1.54	Glass or white onyx.	Blue sheen, opalescent.
Garnet	Complex silicate	Brown, black, yellow, green, ruby red, or orange	Small to medium	Low to high	6.5-7.5	3.15-4.30	Single strained	1.79-1.98	Synthetics, spinel, glass	Single refraction, anomalous strain.
Jade:										
Jadeite	do.	Green, yellow, black, white, or mauve	Large	Low to very high	6.5-7.0	3.3-3.5	Cryptocry stalline	1.65-1.68	Onyx, bowenite, vesuvianite, grossularite	Luster, spectrum, translucent, to opaque.
Nephrite	Complex hydrous silicate	do.	do.	do.	6.0-6.5	2.96-3.10	do.	1.61-1.63	do.	Do.

See footnotes at end of table.

TABLE 1--Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size1/	Cost2/	Mohs	Specific gravity	Refraction	Refractive index	May be confused with-	Recognition characters
Opal	Hydrous silica	Colors flash in white gray, black, red, or yellow	Large	Low to high	5.5-6.5	1.9-2.3	Isotropic	1.45	Glass, synthetics, triplets	Play of color.
Pearl	Calcium carbonate	White, pink, or black	Small	do.	2.5-4.0	2.6-2.85	--	--	Cultured and imitation	Luster, structure, X-ray.
Peridot	Iron magnesium silicate	Yellow and/or green	Any	Medium	6.5-7.0	3.27-3.37	Double (strong)	1.65-1.69	Tourmaline chrysoberyl	Strong double refraction, low dichroism.
Quartz:										
Agate	Silica	Any color	Large	Low	7.0	2.58-2.64	--	--	Glass, plastic, Mexican onyx	Cryptocrystalline, irregularly banded, dendritic inclusions.
Amethyst	do.	Purple	do.	Medium	7.0	2.65-2.66	Double	1.55	do.	Refractive index, double refraction, transparent.
Cairngorm	do.	Smoky	do.	Low	7.0	2.65-2.66	do.	1.55	do.	Do.
Citrine	do.	Yellow	do.	Low	7.0	2.65-2.66	do.	1.55	do.	Do.
Crystal, rock	do.	Colorless	do.	Low	7.0	2.65-2.66	do.	1.55	do.	Do.
Jasper	do.	Uniform or spotted red, yellow, or green	do.	Low	7.0	2.58-2.66	--	--	do.	Opaque, vitreous.
Onyx	do.	Many colors	do.	Low	7.0	2.58-2.64	--	--	do.	Uniformly banded.
Rose	do.	Pink, rose red	do.	Low	7.0	2.65-2.66	do.	1.55	do.	Refractive index, double refraction, translucent.
Spinel	Magnesium aluminum oxide	Any	Small to medium	Medium	8.0	3.5-3.7	Single	1.72	Synthetic, garnet	Refractive index, single refraction, inclusions.
Spinel, Synthetic	do.	Any	Up to 40 carats	Low	8.0	3.5-3.7	Double	1.73	Spinel, corundum, beryl, topaz, alexandrite	Weak double refraction, curved striae, bubbles.
Spodumene:										
Kunzite	Lithium aluminum silicate	Pink to lilac	Medium	Medium	6.5-7.0	3.13-3.20	Double	1.66	Amethyst, morganite	Refractive index.
Hiddenite	do.	Yellow to green	do.	do.	6.5-7.0	3.13-3.20	do.	1.66	Synthetic spinel	Do.

See footnotes at end of table.

TABLE 1--Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size1/	Cost2/	Mohs	Specific gravity	Refraction	Refractive index	May be confused with-	Recognition characters
Tanzanite	Complex silicate	Blue	Small	High	6.0-7.0	3.30	do.	1.69	Sapphire, synthetics.	Strong trichroism.
Topaz	do.	White, blue, green	Medium	Low to medium	8.0	3.4-3.6	do.	1.62	Beryl, quartz	Refractive index.
Tourmaline	do.	All, including mixed	do.	do.	7.0-7.5	2.98-3.20	do.	1.63	Peridot, beryl, corundum, glass	Double refraction, refractive index.
Turquoise	Copper aluminum phosphate	Blue to green	Large	Low	6.0	2.60-2.83	do.	1.63	Glass, plastics	Difficult if matrix not present, matrix usually limonitic.
Zircon	Zirconium silicate	White, blue, or brown, yellow, or green	Small to medium	Low to medium	6.0-7.5	4.0-4.8	Double (strong)	1.79-1.98	Diamond, synthetics, topaz, aquamarine	Double refraction, strongly dichroic, wear on facet edges.

1/ Small-up to 5 carats; medium-up to 50 carats; large-more than 50 carats.

2/ Low-up to $25 per carat; medium-up to $200 per carat; high-more than $200 per carat.

TABLE 2
SYNTHETIC GEMSTONE PRODUCTION METHODS

Gemstone	Production methods	Company	Date of first production
Ruby	Flux	Chatham	1950's
Do.	do.	Kashan	1960's
Do.	do.	J.O. Crystal (Ramaura)	1980's
Do.	do.	Douras	1990's
Do.	Zone melt	Seiko	1980's
Do.	Melt pulling	Kyocera (Inamori)	1970's
Do.	Verneuil	Various producers	1900's
Star ruby	do.	Linde (Div. of Union Carbide)	1940's
Do.	Melt pulling	Kyocera	1980's
Do.	do.	Nakazumi	1980's
Sapphire	Flux	Chatham	1970's
Do.	Zone melt	Seiko	1980's
Do.	Melt pulling	Kyocera	1980's
Do.	Verneuil	Various producers	1900's
Star sapphire	do.	Linde	1940's
Emerald	Flux	Chatham	1930's
Do.	do.	Gilson	1960's
Do.	do.	Kyocera	1970's
Do.	do.	Seiko	1980's
Do.	do.	Lennix	1980's
Do.	do.	Russia	1980's
Do.	Hydrothermal	Lechleitner	1960's
Do.	do.	Regency	1980's
Do.	do.	Biron	1980's
Do.	do.	Russia	1980's
Alexandrite	Flux	Creative crystals	1970's
Do.	Melt pulling	J.O. Crystal	1990's
Do.	do.	Kyocera	1980's
Do.	Zone melt	Seiko	1980's
Cubic zirconia	Skull melt	Various producers	1970's

TABLE 3
VALUE OF U.S. GEMSTONE PRODUCTION, BY GEMSTONE 1/

(Thousand dollars)

Gem materials	1993	1994
Agate	1,410	234
Beryl	470	492
Coral (all types)	166	88
Diamonds	--	284
Garnet	233	780
Gem feldspar	701	2,620
Geode/nodules	207	127
Obsidian	10	40
Opal	639	1,120
Peridot	1,520	635
Petrified wood	234	208
Quartz	1,040	1,060
Sapphire/ruby	313	2,810
Shell	--	33,000
Topaz	8	13
Tourmaline	9,530	14
Turquoise	3,040	1,710
Total	19,500	45,200

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 4
PRICES OF U.S. CUT DIAMONDS, BY SIZE AND QUALITY

Carat weight	Description, color 1/	Clarity 2/ (GIA terms)	Price range per carat 3/ Jan. 1994-Jan. 1995	Average 4/ July 1994
0.25	G	VS1	$1,400 - 1,400	$1,400
.25	G	VS2	1,200 - 1,300	1,200
.25	G	SI1	970 - 975	970
.25	H	VS1	1,200 - 1,300	1,200
.25	H	VS2	1,100 - 1,150	1,100
.25	H	SI1	950 - 950	950
.50	G	VS1	3,050 - 3,050	3,050
.50	G	VS2	2,700 - 2,700	2,700
.50	G	SI1	2,400 - 2,400	2,400
.50	H	VS1	2,800 - 2,800	2,800
.50	H	VS2	2,600 - 2,600	2,600
.50	H	SI1	2,300 - 2,300	2,300
.75	G	VS1	3,650 - 3,650	3,650
.75	G	VS2	3,350 - 3,350	3,350
.75	G	SI1	2,950 - 2,950	2,950
.75	H	VS1	3,250 - 3,250	3,250
.75	H	VS2	2,950 - 2,950	2,950
.75	H	SI1	2,750 - 2,750	2,750
1.00	G	VS1	4,800 - 4,800	4,750
1.00	G	VS2	4,250 - 4,250	4,200
1.00	G	SI1	3,850 - 3,850	3,800
1.00	H	VS1	4,250 - 4,250	4,200
1.00	H	VS2	4,050 - 4,050	4,000
1.00	H	SI1	3,750 - 3,750	3,700

1/ Gemological Institute of America (GIA) color grades: D- -colorless; E- -rare white; G - H - I - -traces of color.

2/ Clarity: IF--no blemishes; VVS1--very, very slightly included; VS--very slightly included; VS2--very slightly included, but not visible; SI1--slightly included.

3/ Jeweler's Circular-Keystone. V. 166, No. 3, Mar. 1995, p. 178.

4/ Jeweler's Circular-Keystone. V. 165, No. 9, Sept. 1994, p. 114.

TABLE 5
PRICES OF U.S. CUT COLORED GEMSTONES, BY SIZE 1/

Gemstone	Carat weight	Price range per carat in 1994 2/	Average price per carat 2/	
			Jan. 1994	Jan. 1995
Amethyst	1	$8 - $18	$13.00	$13.00
Aquamarine	1	75 - 90	82.50	82.50
Emerald	1	1,750 - 3,200	2,750.00	2,475.00
Garnet, tsavorite	1	600 - 900	750.00	750.00
Ruby	1	2,450 - 3,900	3,900.00	3,175.00
Sapphire	1	800 - 1,800	1,400.00	1,300.00
Tanzanite	1	115 - 200	150.00	157.50
Topaz	1	3 - 9	7.00	4.00
Tourmaline, red	1	60 - 125	92.50	92.50

1/ Fine quality.

2/ Jewelers' Circular-Keystone. V. 166, No. 3, Mar. 1995, p. 175. These figures represent a sampling of net prices that wholesale colored stone dealers in various U.S. cities charged its cash customers during the month for fine-quality stones.

TABLE 6
U.S. EXPORTS AND REEXPORTS OF DIAMOND (EXCLUSIVE OF INDUSTRIAL DIAMOND), BY COUNTRY 1/

Country	1993		1994	
	Quantity (carats)	Value 2/ (millions)	Quantity (carats)	Value 2/ (millions)
Exports and reexports:				
Belgium	444,000	363.9	462,000	430.1
Canada	243,000	33.6	263,000	46.0
France	9,210	10.5	11,100	26.9
Hong Kong	232,000	333.5	192,000	401.7
Israel	320,000	286.7	413,000	393.2
Japan	88,800	144.5	55,000	134.4
Singapore	14,600	35.7	14,000	35.5
Switzerland	36,600	160.4	36,200	189.9
Thailand	58,500	24.4	41,300	18.8
United Kingdom	13,900	43.5	23,300	65.8
Other	170,000	62.3	110,000	48.7
Total	1,630,000	1,499.1	1,620,000	1,791.3

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Customs value.

Source: Bureau of the Census, U.S. Department of Commerce.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF DIAMOND, BY KIND, WEIGHT, AND COUNTRY 1/

Kind, range, and country of origin	1993 Quantity (carat)	1993 Value 2/ (millions)	1994 Quantity (carat)	1994 Value 2/ (millions)
Rough or uncut, natural: 3/				
Belgium	144,000	$111.7	301,000	$174.4
Brazil	55,200	4.7	15,300	3.8
Israel	13,500	5.7	23,100	14.9
Netherlands	1,610	2.6	109	0.1
South Africa, Republic of	26,100	43.7	34,800	42.9
Switzerland	8,550	12.6	1,960	7.8
United Kingdom	1,130,000	229.3	482,000	224.8
Venezuela	161	0.1	556	0.1
Other	394,000	199.6	576,000	320.8
Total	1,770,000	610.1	1,440,000	789.7
Cut but unset, not more than 0.5 carat:				
Belgium	952,000	315.7	849,000	235.6
Brazil	5,930	2.0	27,000	3.7
Canada	5,710	1.5	10,000	2.1
Hong Kong	147,000	40.8	145,000	30.2
India	5,580,000	1,178.7	6,150,000	1,125.7
Israel	800,000	347.8	880,000	359.9
Netherlands	1,780	0.4	--	--
South Africa, Republic of	5,660	5.4	3,680	2.5
Switzerland	8,360	2.8	5,260	2.1
United Kingdom	3,150	0.6	9,750	2.1
Other	110,000	25.7	83,300	21.0
Total	7,620,000	1,921.4	8,160,000	1785.0
Cut but unset, over 0.5 carat:				
Belgium	677,000	912.2	769,000	1,026.5
Hong Kong	33,000	44.6	29,000	43.0
India	100,000	63.4	248,000	143.4
Israel	1,160,000	1,255.7	1,350,000	1,570.3
Netherlands	2,180	6.8	491	2.6
South Africa, Republic of	11,800	34.4	19,700	53.5
Switzerland	11,700	114.1	16,900	153.4
United Kingdom	14,000	35.9	14,600	45.1
Other	75,900	97.7	78,300	121.0
Total	2,090,000	2,564.8	2,520,000	3,159.0

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Customs value.

3/ Includes some natural advanced diamond.

Source: Bureau of the Census, U.S. Department of Commerce.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES, OTHER THAN DIAMOND, BY KIND AND COUNTRY 1/

Kind and country	1993		1994	
	Quantity (carats)	Value 2/ (millions)	Quantiy (carats)	Value 2/ (millions)
Emerald:				
Belgium	8,120	$2.1	8,360	$2.0
Brazil	1,100,000	4.0	1,140,000	6.7
Colombia	581,000	118.9	928,000	89.1
France	490	1.0	1,590	1.7
Germany	66,900	2.3	106,000	4.3
Hong Kong	272,000	21.5	295,000	12.9
India	2,090,000	26.8	2,310,000	32.8
Israel	447,000	27.9	107,000	25.4
Japan	1,440	0.2	1,940	0.6
South Africa, Republic of	660	1.0	249	0.1
Switzerland	105,000	24.1	33,200	28.1
Taiwan	581	2.5	545	0.4
Thailand	706,000	6.8	558,000	10.1
United Kingdom	6,680	0.5	4,300	4.0
Other	64,100 r/	4.8 r/	169,000	9.2
Total	5,450,000	244.4	5,670,000	227.2
Ruby:				
Belgium	4,930	0.7	26,900	1.6
Brazil	7,220	0.1	5,670	0.1
Colombia	616	0.6	7,390	0.1
France	629	0.7	393	0.7
Germany	102,000	1.2	90,900	2.6
Hong Kong	218,000	6.2	171,000	6.7
India	1,010,000	2.8	1,480,000	6.9
Israel	14,900	1.8	81,300	0.9
Japan	2,750	0.1	3,170	0.2
Switzerland	19,700	15.7	24,500	13.8
Thailand	2,180,000	47.9	2,950,000	55.8
United Kingdom	3,780	2.5	2,770	2.1
Other	35,800 r/	10.3	25,900	4.3
Total	3,600,000	90.6	4,860,000	95.9
Sapphire:				
Australia	12,400	0.1	27,200	0.5
Austria	335	(3/)	229	0.5
Belgium	18,700	0.8	16,300	1.7
Brazil	2,590	0.1	12,300	0.1
Canada	48,600	0.8	274,000	0.6
Colombia	642	0.2	7,240	0.8
France	607	0.8	739	0.1
Germany	123,000	1.0	130,000	2.6
Hong Kong	203,000	3.7	172,000	4.8
India	156,000	0.6	244,000	2.0
Israel	30,600	1.0	34,500	1.1
Japan	17,700	0.1	1,950	0.3
Singapore	1,090	0.1	8,880	0.1
Sri Lanka (ceylon)	196,000	4.5	341,000	7.7
Switzerland	32,800	7.8	17,000	12.1
Thailand	4,260,000	54.1	5,740,000	62.3
United Kingdom	5,400	0.8	7,130	1.6
Other	24,800 r/	2.8 r/	31,600	1.8
Total	5,130,000	79.3	7,060,000	100.9

See footnotes at end of table.

TABLE 8--Continued.
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES, OTHER THAN DIAMOND, BY KIND AND COUNTRY 1/

Kind and country	1993 Quantity (carats)	1993 Value 2/ (millions)	1994 Quantity (carats)	1994 Value 2/ (millions)
Other:				
Rough, uncut:				
Australia	NA	$3	NA	$3
Brazil		20		27.0
Colombia		6		6.0
Hong Kong		2		1
Nigera		(3/)		(3/)
Pakistan		1		2.0
South Africa, Republic of		2		1
Switzerland		--		--
United Kingdom		--		--
Zambia		1		1
Other	21,800,000 r/	10 r/	30,500,000	10
Total	56,200,000 r/	50 r/	97,400,000	50
Cut, set and unset:				
Australia	NA	4	NA	4.0
Brazil		7 r/		8
Canada		--		1
China		2 r/		4
Germany		10 r/		20
Hong Kong		20 r/		20
India		8.0 r/		10
Japan		10 r/		10
Switzerland		1		2
Taiwan		4 r/		3
Thailand		20 r/		20
United Kingdom		--		--
Other	--	16.0 r/	--	20
Total	NA	100 r/	NA	100

r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Customs value.

3/ Less than 1/2 unit.

Source: Bureau of the Census, U.S. Department of Commerce.

TABLE 9
VALUE OF U.S. IMPORTS OF SYNTHETIC AND IMITATION GEMSTONES, INCLUDING PEARLS, BY COUNTRY

(Million dollars) 1/

Country	1993	1994
Synthetic, cut but unset:		
Australia	3.4	2.7
Austria	3.7	5.0
China	0.7	0.9
France	1.0	1.0
Germany	10.7	10.9
Hong Kong	2.0	1.9
Italy	0.4	0.7
Japan	1.6	1.1
Korea, Republic of	2.1	1.5
Sri Lanka (ceylon)	0.7	0.7
Switzerland	3.8	3.5
Thailand	12.5	10.0
Other	1.4	1.2
Total 2/	44.1	41.1
Imitation:		
Austria	45.9	48.1
China	0.6	0.4
Germany	2.0	2.2
Japan	0.7	0.6
Taiwan	0.8	0.7
The Czech Republic	9.0	10.0
Other	0.7	0.7
Total 2/	60.0	62.7

1/ Customs value.

2/ Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES 1/

(Thousand carats and thousand dollars)

	1993		1994	
Stones	Quantity	Value 2/	Quantity	Value 2/
Diamonds:				
Rough or uncut	1,770	610,000	1,440	790,000
Cut but unset	9,700	4,490,000	10,700	4,940,000
Emeralds: Cut but unset	5,450	244,000	5,670	227,000
Coral and similar materials, unworked	2,800	5,440	2,400	4,630
Rubies and sapphires: Cut but unset	8,730	170,000	11,900	197,000
Pearls:				
Natural	--	2,890	--	2,360
Cultured	--	20,500	--	24,700
Imitation	--	1,960	--	1,870
Other precious and semiprecious stones:				
Rough, uncut	559,000	38,400	971,000	44,100
Cut, set and unset	--	80,800	--	94,600
Other	175	5,870	157	5,000
Synthetic:				
Cut but unset	163,000	44,100	178,000	41,000
Other	--	1,520	--	1,660
Imitation gemstone	--	58,100	--	60,900
Total	XX	5,770,000 r/	XX	6,440,000

r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Customs value.

Source: Bureau of the Census, U.S. Department of Commerce.

TABLE 11
NATURAL DIAMOND: WORLD PRODUCTION, BY TYPE AND COUNTRY 1/ 2/

(Thousand carats)

Country	1990			1991		
	Gem 3/	Industrial	Total	Gem 3/	Industrial	Total
Angola 4/	1,060	73	1,130	899	62	961
Australia	17,300	17,300	34,700	18,000	18,000	36,000
Botswana	12,200	5,200	17,400	11,600	4,950	16,500
Brazil	600	900	1,500	600	900	1,500 e/
Central African Republic	303	78	381	296	82	378 r/
China e/	200	800	1,000	200	800	1,000
Gabon e/	400	100	500	400	100	500
Ghana	520	130	650	560	140	700
Namibia	750	15	763	1,170	20	1,190
Russia e/	XX	XX	XX	XX	XX	XX
Sierra Leone 5/	66	12	78	160	83	243
South Africa, Republic of	3,900 r/	4,800 r/	8,710	3,800 r/	4,600 r/	8,430
U.S.S.R. e/ 6/	12,000	12,000	24,000	10,000	10,000	20,000
Venezuela	85	248	333	102	112	214
Zaire	2,910	16,500	19,400	3,000	14,800	17,800
Total	48,400	53,400	102,000	46,900	50,000	97,000
Other	4,180	4,950	9,100	4,080	4,770	8,870
Grand total	52,600 r/	58,400 r/	111,000 r/	51,000 r/	54,800	106,000 r/

	1992			1993		
	Gem 3/	Industrial	Total	Gem 3/	Industrial	Total
Angola 4/	1,100	80	1,180	130 r/	15 r/	145 r/
Australia	18,100 r/	22,100 r/	40,200 r/	18,800 r/	23,000 r/	41,900 r/
Botswana	11,200	4,790	15,900	10,300 r/	4,420 r/	14,700 r/
Brazil	653	665	1,320	600	900	1,500 e/
Central African Republic	307	107	414	370 r/	125 r/	495 r/
China e/	200	800	1,000	230	850	1,080
Gabon e/	400	100	500	400	100	500
Ghana	570	140	710	570 r/	140 r/	710 r/ e/
Namibia	1,520 r/	30 r/	1,550	1,120 r/	20 r/	1,140
Russia e/	9,000	9,000	18,000	8,000	8,000	16,000
Sierra Leone 5/	180 r/	116 r/	296	90	68	158
South Africa, Republic of	4,600 r/	5,600 r/	10,200 r/	4,600 r/	5,700 r/	10,300
U.S.S.R. e/ 6/	XX	XX	XX	XX	XX	XX
Venezuela	302	176	478	145 r/	155 r/	301 r/
Zaire	8,930	4,570	13,500	2,010 r/	13,600 r/	15,600 r/
Total	52,400	42,700	95,100	42,800	51,400	94,300
Other	4,880	5,800	11,300	4,860	5,900	10,800
Grand total	57,300 r/	48,500 r/	106,000 r/	47,700 r/	57,300 r/	105,000 r/

See footnotes at the end of table.

TABLE 11--Continued
NATURAL DIAMOND: WORLD PRODUCTION, BY TYPE AND COUNTRY 1/ 2/

(Thousand carats)

	1994 e/		
Country	Gem 3/	Industrial	Total
Angola 4/	270	30	300
Australia	19,500	23,800	43,300
Botswana	11,000	5,000	16,000
Brazil e/	600	900	1,500
Central African Republic	370	125	495
China e/	230	850	1,080
Gabon e/	400	100	500
Ghana	580	145	725
Namibia	1,280	30	1,310 7/
Russia e/	8,500	8,500	17,000
Sierra Leone 5/	155	100	255
South Africa, Republic of	5,000	5,800	10,600 7/
U.S.S.R. e/ 6/	XX	XX	XX
Venezuela	220	175	395
Zaire	4,000	13,000	17,000
Total	47,100	52,800	99,900
Other	5,230	5,910	11,200
Grand total	52,300	58,700	111,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data have been rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 30, 1995. Total natural diamond output (gem plus industrial) for each country actually is reported, except where indicated by a footnote to be estimated. In contrast, the detailed separate production data for gem diamond and industrial diamond are U.S.Bureau of Mines estimates except Brazil (1990) and Central African Republic (1990-93), for which source publications give details on grade as well as totals. The estimated distribution of total output between gem and industrial diamond is conjectural, and for most countries, is based on the best available data at time of publication.

3/ Includes near-gem and cheap-gem qualities.

4/ Figures do not include smuggled artisanal production.

5/ Figures are estimates based on reported exports and do not include smuggled diamonds.

6/ Dissolved in Dec. 1991.

7/ Reported figure.

GERMANIUM

By Errol D. Sehnke

Germanium is a grayish-white, metallic element with the physical properties of a semiconductor, i.e.-electrical characteristics between those of a metal and an insulator. It is commercially available as a tetrachloride, a high-purity oxide, and in the form of zone-refined ingots, single-crystal bars, castings, doped semiconductors, optical materials, optical blanks, and other specialty products.

Domestic refinery production and consumption for germanium are estimated by the U.S. Bureau of Mines (USBM) on the basis of discussions with domestic producers. Estimated domestic refinery production of germanium in 1994 remained at approximately the same level as reported for 1993, while U.S. consumption was estimated to have dropped by approximately 14% in 1994. This lower consumption level was chiefly attributed to a continuing reduction in the U.S. defense establishment's requirements for infrared systems.

The importance of germanium as a strategic and critical material has been recognized by the Federal Emergency Management Agency. On July 6, 1984, it was included in the National Defense Stockpile (NDS) with an initial goal of 30,000 kilograms of germanium metal. On July 24, 1987, a new NDS goal of 146,000 kilograms was established. This goal was later adjusted downward and, as of December 31, 1994, the NDS inventory was 68,207 kilograms of germanium metal with 7 kilograms authorized for future disposal.

In a related matter, the American Mining Congress, through a series of letters to U.S. legislators, recommended that several materials in the NDS, including germanium, be considered as candidates for upgrading or additional processing to provide the highest purity materials suitable for stockpile storage. Despite this request, there were no metal upgrades included in the Defense Department's Annual Materials Plan for fiscal year 1995.

Production

The USBM estimated domestic refinery production from primary and secondary materials in 1994 to be 10,000 kilograms, about the same as in 1993.

In 1994, Eagle-Picher Industries Inc.'s Quapaw, OK, Specialty Materials Div. remained the only producer in the United States that recovered primary germanium from zinc smelter residues. Eagle-Picher also reprocessed germanium scrap. Cabot Corp., Revere, PA, and Atomergic Chemetals Corp., Plainview, NY, produced germanium from reprocessed scrap and semirefined foreign material. Early in 1994, Union Minière of Belgium sold its zinc mining and refining operations in the United States to the Australian group, Savage Resources Ltd. Under the new management, the Clarksville, TN, zinc refinery continued to produce germanium-rich residues as a byproduct of processing zinc ores from the new group's associated Elmwood-Gordonville Mine. In addition the new operating company, Savage Zinc, Inc., continued the established procedure of shipping these residues to Union Miniere's Germanium Business Unit in Belgium for germanium recovery and refining.

Consumption

The USBM estimated consumption of germanium in 1994 at 25,000 kilograms, compared with about 29,000 kilograms in 1993. The estimated consumption pattern in 1994 was as follows: fiber optics, 35%; infrared systems, 20%; gamma-ray, X-ray, and infrared detectors, 10%; semiconductors (including transistors, diodes, and rectifiers), 10%; and other applications (catalysts, phosphors, metallurgy, and chemotherapy), 25%.

Fiber optics and infrared optical systems continued to be the dominant end uses for germanium. In the fiber optics sector, germanium was employed as a dopant within the core of many optical fibers used by the telecommunications industry. In addition, germanium-containing lenses and windows are transparent to infrared radiation, a property that has led to their use in infrared optical systems. These optics are employed principally for military guidance and weapon-sighting applications. Germanium glass also was used for nonmilitary surveillance and monitoring systems in fields such as satellite systems and fire alarms.

Prices

In 1994, domestic producer prices for germanium metal and dioxide were estimated to have remained at the levels established in late 1981 ($1,060 and $660 per kilogram, respectively). However, discounting by producers because of competition from imported materials was evident.

Free market prices, published by Metal Bulletin (London), remained in a low range of $340 to $350 per kilogram. The price for Belgian- produced germanium metal, published by Metal Bulletin (London), started the year at about $860 per kilogram and dropped to the $600-$660 range from August 24, 1994, onward.[1]

Foreign Trade

In 1994, the estimated germanium content of imports was approximately 14,000 kilograms. Total imports of germanium materials decreased modestly compared with those of 1993. China, Russia, Ukraine, Estonia, Germany, and Belgium, in descending order of shipments, accounted for approximately 87% of the total U.S. germanium imports for 1994. (See table 1.)

World Review

World refinery production was estimated at 50,000 kilograms in 1994, the same as in 1993. This sluggishness in world production was attributed to an oversupply and to a lower level of demand for the metal. The total world germanium refinery capacity for 1994 was estimated at 270 metric tons.

Belgium.—Metal Bulletin reported at the end of 1994 that Union Minière had decided to discontinue quoting a market price for 50 ohm-cm germanium metal ingot. The company, however, intended to continue to carry a quote for the price of germanium dioxide.

Germany.—Researchers at Siemens reported the development of a new photovoltaic light-stable semiconductor material based on amorphous germanium. The germanium/silicon-based material does not age under the action of light. In addition, it is highly photosensitive and is particularly suitable for red-sensitive photovoltaic components.

Japan.—Roskill's Letter from Japan reports that Japanese demand for germanium dioxide used in catalysts for the production of polyethylene terephthalate (PET) resin was firm in 1994, because of a 5% increase in the output of PET. The production of PET resin accounts for over one- half of Japanese consumption of germanium dioxide.

Japanese regulatory authorities reportedly approved Sanwa Kagaku Kenkyusho's new organic germanium (propagermanium) medication for the treatment of chronic hepatitus B infection. While this orally active agent has no direct antiviral activity, it appears to act by stimulating killer T cells and macrophages to produce interleukins and interferons, which thereby inhibit the growth and spread of the virus.

Plans were released in June by Japan's Ministry of Posts and Telecommunications (MPT) for a multibillion dollar effort to rewire every home and business in Japan with state-of-the-art fiber optics by the year 2010.

Russia.—As reported in Photonics Spectra, plans are under consideration by the Russian Ministry of Posts and Telecommunications for a major telecommunications expansion program in Russia that will entail laying some 76,000 kilometers of new fiber optic lines over the next 10 years.

In addition, it was reported by Haznews that the Gai Mining and Dressing Works near Orsk, in the Orenburg region of Russia, was seeking Western partners to process some 40 million tons of mine and concentrator tailings containing copper, zinc, and germanium.

Outlook

In 1994, for the sixth consecutive year, the supply of germanium exceeded the demand for this specialty metal. Nevertheless, it is possible that future germanium supplies may become tight if the expanded demand for the fiber optics sector develops as has been projected and if sources of supply in the newly independent republics of the former Soviet Union encounter substantial disruption. If this supply-demand situation develops, prices of processed germanium may be expected to increase in the near term.

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[1] Where necessary, values have been converted from Belgian francs (BF) to U.S. dollars at the average exchange rate of BF33.5=US$1.00.

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Other Sources

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TABLE 1
U.S. IMPORTS OF GERMANIUM MATERIALS 1/, BY COUNTRY 2/

Country	1993 Gross weight (kilograms)	1993 Value	1994 Gross weight (kilograms)	1994 Value
Belgium	1,400	$2,430,000	1,400	$1,850,000
Canada	--	--	22	2,200
China	2,780	565,000	2,950	672,000
Czech Republic	202	36,400	--	--
Estonia	--	--	1,930	362,000
Finland	248	50,800	--	--
France	207	108,000	305	117,000
Germany	1,630	518,000	1,900	686,000
Hong Kong	982	313,000	--	--
Israel	216	110,000	273	158,000
Italy	--	--	70	11,300
Japan	1	4,690	--	--
Netherlands	--	--	139	23,600
Russia	1,960	275,000	2,370	439,000
Switzerland	--	--	5	1,750
Ukraine	5,030	649,000	2,340	545,000
United Kingdom	839	239,000	1,020	270,000
Total 2/	15,500	5,300,000	14,700	5,140,000

1/ Unwrought and waste and scrap.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

GOLD

By John M. Lucas

World gold production declined in 1994. The Republic of South Africa remained the world's largest gold producing nation, followed, despite a slight decline in production, by the United States, which has been the second largest producer since 1991 when its production, for the first time in nearly five decades, surpassed that of the former Soviet Union. Nevada, followed by California, continued to be the dominant gold-producing States, where combined output for 1994 accounted for nearly 75% of the U.S. total. Though most domestic gold mines were surface or open pit operations, conversion to underground methods had begun to accelerate as more near-surface deposits reached depletion. Some of the deeper deposits, accessible only by underground methods, contain higher grade sulfide ores which require more extensive preparation than ores encountered in most near-surface operations. Although most of the Nation's gold mines were in Western States, a few continued to operate in States east of the Mississippi River. Gold also was produced at a dozen or more large placer mines, nearly all in Alaska, and numerous small placer mines, mostly in Alaska and Western States. A small amount of domestic gold also was produced as a byproduct of processing the ores of base metals, chiefly copper. Twenty-five mines yielded 80% of the gold produced. The value of U.S. gold mine production in 1994 was more than $4 billion.

Domestic gold exploration activity, which generally peaked during the late 1980's, continued to decline, as mining companies pursued opportunities in other nations. In several Latin American nations, for example, favorable geology, combined with recently liberalized mining regulations attracted an influx of United States and other foreign gold exploration and development spending. Recent overseas exploration interest and spending by U.S. firms also was directed toward various western Pacific regions and several areas of the former Soviet Union.

Conversion of old gold scrap to refined gold provided about 74 metric tons(4.7 million troy ounces[1]) of metal to the market, a quantity equivalent to nearly all domestic gold consumption. The balance of secondary production, 73 tons, was from prompt industrial scrap, partly toll refined.

Commercial-grade refined gold came from about 2 dozen producers. A few dozen companies, out of several thousand companies and artisans, dominated the fabrication of gold into useful products. Nearly all jewelry manufacturing was centered in the New York, NY, and Providence, RI, areas. Estimated uses in 1994 were as follows: jewelry and arts, 70%; industrial (mainly electronics), 23%; and dental, 7%.

The Engelhard Industries/London daily price of gold ranged from a low of about $370 per troy ounce on April 22, to a high of nearly $398 on September 28. The average for the year was about $385. The previous year's prices ranged from about $327 to $407 and averaged about $361.

Identified world gold resources at yearend 1994 were estimated by the U.S. Geological Survey at 75,000 tons, of which 15% to 20% was byproduct resources. The world reserve base was estimated by the U.S. Bureau of Mines (USBM) at 60,000 tons and reserves at 44,000 tons. The Republic of South Africa had about one-half of the resources and reserve base and 41% of the reserves. The United States had about 12% of world resources, 9% of the reserve base, and 11% of the reserves.

Of an estimated 116,000 tons of gold mined in historical times through 1994, about 15% is believed to have been lost, used in dissipative industrial uses, or otherwise unrecoverable or unaccounted for. Of the remaining 99,000 tons, an estimated 35,000 tons are official stocks held by central banks, and about 64,000 tons are privately held as coin, bullion, and jewelry.

Production

Domestic mine production data for gold are developed by the USBM from two separate, voluntary surveys of U.S. operations. One of these surveys is the lode-mine production survey of copper, gold, lead, silver, and zinc mines. Of the lode gold producers in operation to which a survey request was sent 206 responded, representing 98% of the total gold shown in tables 1 and 2. The individual company production and performance data in this report were derived from published sources such as company annual reports.

Of the total gold produced during 1994, 93% was extracted from gold ore while the remainder was derived from base metal and other precious metal ores and from placer deposits. By comparison, similar data assembled for 1980 indicated that gold ores provided 63% of the total gold produced and the remainder, 37%, was derived from base metal and other precious metal ores and placers. In both years, 1980 and 1994, the contribution from placer mines amounted to less than 2% of the total gold produced.

Alaska.—Gold developments in Alaska during 1994 were summarized in a report on Alaskan mining activity prepared by the Alaska State Division of Geology and Geophysical Surveys (DGGS),[2] in cooperation with the Alaska Department of Commerce and Economic Development. According to the DGGS, there were approximately 185 mechanized placer mines in operation during the year compared with 196 during 1993, and for the first time in 15 years, all of Alaska's gold production was derived exclusively from placer mines.

According to the DGGS, the 10 largest Alaskan gold mines accounted for 58% of 1994 production. The State reported that Silverado Mines Ltd. recovered a 41.3 ounce (1,285 gram) nugget at its underground placer operations at the Nolan Mine; the nugget was unofficially determined to be the 10th largest placer gold nugget recovered in Alaskan mining history.

Gold exploration and the development and permitting of new gold mines continued to increase in Alaska. Echo Bay Mines Ltd. continued exploration and development of the A-J Mine on the outskirts of Juneau and at its Kensington joint-venture project 115 kilometers (72 miles) north of Juneau. Amax

Gold Inc. gained Federal permit approval for its Fort Knox Project 24 kilometers (15 miles) northeast of Fairbanks. On Ester Dome 13 kilometers (8 miles) northeast of Fairbanks, La Teko Resources Ltd. continued exploration of its True North property.

California.—California's largest gold mine, the McLaughlin Mine of Homestake Mining Co., processed oxide and sulfide ore mined by open pit methods to recover nearly 7.8 tons (250,453 ounces) of gold during 1994. The State's second-largest gold mine, Santa Fe Pacific Gold Corp.'s Mesquite Mine, produced 6.5 tons (207,508 ounces) of gold from open pit operations near Brawley in Imperial County. In eastern Imperial County, Glamis Gold Ltd. produced gold by heap leaching at its Picacho Mine and conducted further exploration at its Imperial Project. Glamis, through its wholly owned Rand Mining Co., also produced gold at its Baltic and Yellow Aster Mines near Randsburg in Kern County. Other mines producing gold in Imperial County during the year included the American Girl Mine and Cactus Mine.

In eastern San Bernardino County near the Nevada/California State line, Viceroy Gold Corp. produced an estimated 5,200 kilograms (168,000 ounces) of gold at its new Castle Mountain Mine.

In the State's Mother Lode country, Sonora Mining Corp. completed mining operations at its Jamestown gold mine at Jamestown in Tuolumne County. In Calaveras County, FMC Gold Co. closed its Royal Mountain King Mine near Copperopolis. To the north, in Nevada County, Siskon Gold Corp. poured its first bar of gold at its new San Juan Mine, an underground placer operation located near Nevada City. Siskon also conducted exploration and permitting operations at its Big Horn Property in Los Angeles County.

In Lassen County, Lassen Gold Mining Inc., a subsidiary of Amax Gold Inc., completed a successful transition from milling to an all heap-leaching operation at its Hayden Hill Mine. Hayden Hill's production during 1994 was nearly 2,050 kilograms (65,785 ounces).

Montana.—According to an annual review of mining and mineral developments in the State, prepared by the Montana Bureau of Mines and Geology (MBMG),[3] exploration activity, largely focused on gold, doubled in 1994. Of the mines producing gold in Montana during the year, three were owned and operated by Pegasus Gold Inc. They were: the Beal Mountain Mine in Silver Bow County, the Montana Tunnels Mine, a gold, lead, silver, and zinc mine in Jefferson County; and the Zortman Mine in Phillips County, the State's largest gold mine in 1994.

In midyear, unstable ground conditions led to the suspension of milling operations at Placer Dome's wholly owned Golden Sunlight Mine near Whitehall in Jefferson County. Remedial measures and repairs occupied most of the time remaining in 1994; full production was resumed in early February 1995.

In Park County, TVX Gold Inc. continued production at its underground Mineral Hill Mine near Jardine and exploration at its nearby Crevice Mountain project. Construction of a 4.3 kilometers (2.7 mile) tunnel connecting the two sites was begun during the year. Also in Park County, about 80 kilometers (50 miles) east of Mineral Hill, Crown Butte Resources Ltd. continued to seek permits for its New World project near Cooke City. Plans for the controversial gold, copper, and silver project north of Yellowstone National Park call for underground mining and ore processing without the use of heap leaching or cyanide recovery methods.

Nevada.—Nevada maintained its long-standing position as the Nation's dominant gold-producing State. Thirteen of the Nation's top 25 gold producing mines during 1994 were in the Silver State.

Barrick Gold Corp., which for the first time became the Nation's largest gold mining company, recovered 57.5 tons (1.85 million ounces) of gold at its Betze-Post Mine in Eureka County. Nearby in Elko County, Barrick continued development of its Meikle Mine, a new underground operation scheduled to begin production during the second half of 1996. Barrick's operations on the Carlin Trend are developed within a 2,800 hectare (7,000 acre) land holding designated collectively as the Goldstrike Property. In late 1994, Barrick acquired full ownership of the Bullfrog Mine in Nye County. During the year Bullfrog produced just over 9,300 kilograms (300,000 ounces) of gold at the mine site near Beatty.

Nearby, both geographically and in terms of production, Newmont Gold Co. (NGC) produced 48.4 tons (1,555,300 ounces) of gold from its operations generally centered in Eureka and Elko Counties. NGC's widespread operations along the Carlin Trend are divided geographically into three management areas: the North Area, which includes the Post, Carlin, and Genesis Mines and mills No. 1 and No. 4; the South Area, which includes the Gold Quarry Mine and mills No. 2 and No. 5; and the Rain Area, which includes the Rain Mine and mill No. 3. Of the tonnage mined, mines in the North Area accounted for 50.7% of the total while 48.1% and 1.2% of the remainder was extracted from deposits in the South Area and the Rain Area, respectively. Of the total gold production reported for the year, 58% was derived by milling and the remainder, 42%, was recovered by heap leaching. During the year NGC completed construction of a new refractory ore treatment plant north of Carlin. Construction was also underway at yearend on an $11 million bioleach demonstration project designed to process lower grade refractory ores.

Northwest of Elko, in Elko County, Independence Mining Co. and FMC Gold Co. produced about 10.2 tons (326,667 ounces) of gold at its Jerritt Canyon Mine. To the west, in Humboldt County, Santa Fe Pacific Gold Corp. (SFPG) recovered 15.6 tons (501,891 ounces) of gold at its Twin Creeks Mine and about 7.1 tons (226,911 ounces) at its Lone Tree Mine to the south near Valmy. Both operations are open pits where gold is recovered by milling and heap leaching, respectively. Nearby, FirstMiss Gold Inc. produced nearly 7.6 tons (243,826 ounces) of gold at its Getchell Mine during the fiscal year ending in midyear. Other gold mines in Humboldt County include the Crowfoot/Lewis Mine, Marigold Mine, Pinson Mine, and Sleeper Mine.

South of and parallel to the Carlin Trend, the Battle Mountain/Eureka Trend runs from southeastern Humboldt County southeast through Eureka in Eureka County. Gold mining operations along this trend include the Battle Mountain Complex of Battle Mountain Gold Co. in Lander County, the McCoy/Cove gold and silver property of Echo Bay Mines Ltd., the Cortez Gold Mine Joint Venture's Cortez Mine, Atlas Corp.'s Gold Bar Mine, placed under temporary shutdown and standby in mid-1994, and Alta Gold Co.'s Easy Junior Mine in White Pine County. Considerable exploration activity continued to be focused on the Pipeline, Ruby Hill, and various other recent discoveries along the Battle Mountain/Eureka Trend in Lander and Eureka Counties.

At Round Mountain, in north-central Nye County, Round Mountain Gold Co. produced about 13.2 tons (423,504 ounces) of gold during the year, an increase of 13% over the previous year. All of the increase came from a new "dedicated" (permanent) heap-leach pad.

South Dakota.—Homestake Mining Company's nearly 12-decade-old Homestake Mine was again the Nation's largest underground gold mine, the largest gold-producing mine in South Dakota, and the sixth largest gold-producing mine in the country. During the year the mine at Lead, a nearly 2.5 kilometer (8,000 foot)-deep operation with associated surface mining, recovered about 12.3 tons (393,934 ounces) of gold at a reported cash production cost of $292 per ounce. Performance for 1994 was impacted by a cave-in and a 100-year record rainstorm which also affected the performance of other Black Hills gold operations.

At Wharf Resources Ltd.'s Wharf Mine, west of Lead, production amounted to a record of nearly 3,300 kilograms (105,282 ounces). Nearby, the company's 60%-held Golden Reward Mine produced about 1,650 kilograms (52,556 ounces) of gold kilogram.

About 74 kilograms (2,400 ounces) of residual gold were recovered by releaching previously leached ore at Dakota Gold Mining Inc.'s Gilt Edge Mine near Deadwood. The company continued exploration and permitting at its Anchor Hill oxide deposit on the Gilt Edge property. Some residual gold also was recovered at Barrick Gold's, formerly Lac Minerals Ltd.'s, Richmond Hill Mine where mining of ore ceased in mid-1992.

In the November elections the electorate of Lawrence County, host county for the aforementioned mines, defeated a ballot initiative to prohibit the issuance of new mining permits, or amendments to existing permits, for surface metal mining projects within designated areas of the County.

Utah.—Kennecott Corp.'s Bingham Canyon Mine, produced gold as a byproduct of its copper mining operations near Salt Lake City. Long ranked as one of the country's leading gold-producing mines, Bingham Canyon was the fourth largest gold producer during 1994. Kennecott also operated the nearby Barney's Canyon Mine, an open pit and heap-leaching operation.

Barrick Gold Corp.'s open pit Mercur Mine in Tooele County, Utah's largest primary gold producer, recovered about 3,360 kilograms (108,107 ounces) of gold in 1994. Mercur presently has a 5-year life remaining and is scheduled to begin closure in 3 years following depletion of all open pit reserves and reclamation of tailings from earlier mining.

USMX Inc. reported that its Goldstrike Mine in Washington County produced about 1,070 kilograms (34,486 ounces) of gold. Mining activities at the site were completed in late 1994. Reclamation of the remaining mining disturbances and residual production from ore in place on the heaps is expected to extend operations into late 1995. There was some gold exploration activity in the State during the year. Most of the activity was centered around former producing mines in the old Tintic Mining District.

World Review

For the first time following 15 consecutive years of growth, world mine production failed to exceed that of the previous year. Increasing production from mines in developing Nations was more than offset by a sharp decline in production from the Republic of South Africa. According to its annual review of world gold supply and demand, Gold Fields Mineral Services Ltd. (GFMS)[4] calculated that total global supplies of gold in 1994 were balanced against total demand for gold at 3,319 tons (107 million ounces) compared with the previous year's total of 3,563 tons (about 115 million ounces). There were several important developments in the individual components of the supply/demand equation in 1994. The most significant development was a dramatic decline in net official/central bank sales of gold to the market; official sector sales declined from 445 tons (14 million ounces) in 1993 to 78 tons (2.5 million ounces) in 1994. Gold Fields noted that supplies of old scrap to market during 1994 rose to the highest level ever recorded in its annual surveys which record the contribution of scrap to the supply side as far back as 1980.

On the demand side of the equation, GFMS reported that the overall fabrication of gold into end products increased slightly from that of the previous year but failed to match the record demand level set in 1992. Gold used in the fabrication of jewelry products globaly rose more than 2% to 2,576 tons (83 million ounces) and gold consumed in electronic products rose more than 5% to 192 tons (about 6 million ounces). Worldwide the use of gold in other demand sectors such as dentistry, medals and imitation coins, and other industrial and decorative applications increased slightly. The use of gold in the minting of official coins declined 41% from the 1993 level. GFMS's data on various facets of the gold investment sector indicated that gold supplies to the market from futures market vehicles, as well as gold calculated to have returned to the market because of disinvestment, more than offset the quantity of gold absorbed by gold loans and gold bars held for investment and hoarding purposes. Bar hoarding registered a substantial increase over quantities estimated to be held at the end of 1993.

Australia.—Australian gold production continued to expand and for the third consecutive year Australia retained its position as the world's third largest gold-producing nation. Of the 256 tons (8.2 million ounces) of gold produced in 1994, Western Australia, Queensland, and the Northern Territory accounted for about 76%, 13%, and 7%, respectively. Western Australia's production was derived primarily from mines situated around and west of Kalgoorlie. Other Australian gold-producing States, in descending order of output, were New South Wales, Victoria, Tasmania, and South Australia.

A number of gold mines were under development or expanding capacity and several new mines began production during the year. In Western Australia, for example, Great Central Mines NL began open pit production at its Bronzewing Mine near Wiluna, and Gold Mines of Australia Ltd. began underground operations at its Youanmi Mine northeast of Perth.

Canada.—Although Canada's gold production decreased for the third consecutive year, new mines under development at yearend 1994 should result, in later years, in a gradual recovery of production to levels seen prior to the decline, according to a review of Canadian gold developments prepared by the Canadian Department of Energy, Mines and Resources.[5] Canada retained its position as the world's fourth largest gold producer. In

1994, gold was produced at about 50 primary gold mines; these accounted for 91% of the total. Base metal mines and placer mines accounted for 6.5% and 2.5%, respectively, of the remainder. Canada's principal gold-producing regions, in descending order of output, were Ontario, Quebec, the Northern Territory, and British Columbia. Gold was also produced in Alberta, Manitoba, New Brunswick, and the Yukon.

Latin America.—Interest in gold exploration opportunities, new mine development activity, and production in many Latin American nations continued to increase during the year. Much of the activity was focused on Chile, Mexico, Peru, and to a lesser extent the Guyanan Shield area of Guyana and Venezuela. There also appeared to be increasing interest in the prospects for expanded gold production in other nations such as Argentina and the nations of Central America and the Caribbean, especially the Republic of Cuba.

Gold production in Brazil, Latin America's largest gold-producing nation, continued to decline as easily worked surface and placer deposits are mined out by independent gold miners or "garimpeiros." Yet to be reflected in Brazil's performance data is the trend toward rising gold production by the formal or corporate sector.

New mines completing a first full year of production included Bolivia's Kori Kolo, Chile's Guanaco, Guyana's Omai, Mexico's Amelia and Rio Yaqui, and Peru's Yanacocha. In Venezuela's El Dorado region, Monarch Resources Ltd. began production in midyear at its La Camorra Mine while in Panama, Greenstone Resources Ltd. began open pit mining at its Santa Rosa Mine and the Eldorado Corp. Ltd. began production at its La Colorada Mine in Mexico.

Oceania.—Gold production in Papua New Guinea declined for the second consecutive year reflecting to some extent the mining of lower grade ores at two of that nation's larger gold mines, Placer Pacific Ltd.'s Porgera and Misima Mines. Conversely, higher grade ores contributed to increased production at BHP Co. Ltd.'s Ok Tedi copper-gold mine. Exploration was continued at a number of gold prospects and in early 1995 the Government issued a Special Mining Lease to RTZ which opened the way for construction of the Lihir Island project off the east coast of New Ireland. Production was also scheduled to begin in 1995 at Dome Resources Ltd.'s Tolukuma project north of Port Moresby.

In Indonesia, gold production increased substantially. Freeport Indonesia Inc. recovered more than 24 tons (784,000 ounces) of byproduct gold at its Grasberg/Ertsberg copper-gold mine in West Irian and PT Kelian Equatorial Mining recovered nearly 14 tons (433,000 ounces) of gold at the Kelian Mine in East Kalimantan. Several new Indonesian gold mines began production in 1994. Gold exploration activities continued to increase and several late-stage projects were being readied for production in the near future.

Gold production in New Zealand was derived from three large surface lode mines and several medium-sized placer mines. Underground mining continued on Fiji's Island of Viti Levu. Some gold exploration was conducted on Espiritu Santo in the Republic of Vanuatu, on New Caledonia, and in the Solomon Islands.

South Africa, Republic of.—During the 35 years prior to 1994 gold production in South Africa, the world's largest gold-producing nation, has ranged from a high of 1,000 tons (32 million ounces) in 1970 to low of 601 tons (19.2 million ounces) in 1991. In 1994, however, problems linked to the beginning of a new post-apartheid government, repeated labor disruptions, escalating costs, and declining ore grades combined to drive the production the lowest level since 1958 when only 549 tons (17.6 million ounces) were produced.

The tonnage and grade of ore milled during 1994 by the nearly 3 dozen mines representing the membership of the Chamber of Mines of South Africa amounted to nearly 99 million metric tons bearing a gold grade of 5.40 grams per ton (0.158 ounce per short ton); this compares with 103 million tons bearing 5.56 grams per ton (0.162 ounce per short ton) milled by Chamber members during the previous year.

The six major corporate groups or "houses" which dominate the South African gold mining industry were as follows: The Anglo American Corp. of South Africa Ltd. (AAC), Gold Fields of South Africa Ltd., Gencor Ltd., Johannesburg Consolidated Investment Co. Ltd., Anglovaal Ltd., and Rand Mines Ltd. The two largest gold mines in terms of production during 1994 were the Freegold and Vaal Reefs, both owned by AAC. The two next largest mines were the Driefontein and Kloof, both owned by Gold Fields.

Russia and the Former U.S.S.R.—Of the seven or more gold-producing independent countries resulting from the dissolution of the U.S.S.R. in late 1991, Russia is by far the largest, both in terms of output and number of operations as well as areal distribution. Much of Russia's production derives from State-owned enterprises and cooperatives, known as artels, scattered throughout eastern Russia.

Foreign corporate involvement in gold exploration, development and mining activity in the former Soviet Union continued to evolve during the year, but at a much lower pace than previously anticipated. Numerous North American, Australian, and European corporations continued to pursue joint-venture opportunities in Kazakhstan, Kyrgyzstan, and elsewhere throughout the former Soviet Union. By late 1994, the Zarafshan-Newmont Joint Venture had nearly completed the preproduction phase at its new gold recovery project at the Muruntau Mine in Uzbekistan; gold production began at a rate of 14 tons (450,000 ounces) per year in mid-1995.

Outlook

The course to be taken by the domestic gold mining industry depends to a large extent upon the outcome of the current legislative debate in the Congress. The effect of revisions to the General Mining Law, which governs mining and exploration on Federal lands, and proposals to impose additional tax and regulatory burdens on mine production from both Federal and non-Federal lands will largely determine the course of future domestic gold mining activity. If new legislation places unacceptable burdens on producers and reduces the incentive to explore, production could decline substantially as existing deposits are high-graded wherever possible, or reclassified as uneconomic, and producers, explorationists, and investors opt to pursue opportunities in more hospitable environments elsewhere. What may be little understood and appreciated in the current debate is that modern metal mining has always been a high risk global pursuit driven by cyclical world market prices and by evolving geologic theories and the accessibility to favorable geologic terrain. The nature of the exploration process, the ability to pursue the development of favorable prospects once discovered, and the long lead times generally required to effect a return on investment are characteristics that must be taken into account whenever the future of the industry is considered.

The USBM released a comprehensive overview of the operation and economics of the gold mining industry worldwide.[6] An overview of the economics and public policy issues affecting the domestic gold mining industry was published in early 1995.[7] The Gold Institute forecasts world gold production to increase at a rate of about 1.6% annually through 1997.[8]

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[1] Ounce refers to troy ounce. One kilogram of gold weighs 32.1507 troy ounces.

[2] Swainbank, R. C., and T. K. Bundtzen. Alaska's Mineral Industry 1994: A Summary. AK Div. Geol. and Geophys. Surv. Inf. Circ. 40, Mar. 1995, 11 pp.

[3] McCulloch, R. Annual Mining Review Mining Eng., v. 47, No. 5, May 1995, pp. 440-441.

[4] Murray, S. K., K. Crisp, P. Klapwijk, T. Sutton-Pratt, and others. Gold 1995. Gold Fields Mineral Services Ltd. (London), May 1995, 64 pp.

[5] Couturier, G. Gold. Advance Copy of Ch. from Canadian Minerals Yearbook—1994. 21 pp.

[6] World Gold, A Minerals Availability Appraisal. U.S. Bureau of Mines Special Pub. SP 24-94, 1994. 197 pp.

[7] Dobra, J. L., and P. R. Thomas. The U.S. Gold Industry 1994. Nevada BuMines and Geol. Special Pub. 18, 1995. 32 pp.

[8] The Gold Institute. World Mine Production of Gold 1993-97. May 1994. 9 pp.

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TABLE 1
SALIENT GOLD STATISTICS 1/

		1990	1991	1992	1993	1994
United States:						
Mine production	kilograms	294,000	294,000	330,000	331,000	326,000
Value	thousands	$3,640,000	$3,430,000	$3,660,000	$3,840,000	$4,040,000
Gold recovered by cyanidation:						
Extracted in vats, tanks, and closed containers 2/		136,000	160,000	178,000	177,000	169,000
Leached in open heaps or dumps 3/		129,000	104,000	120,000	128,000	119,000
Refinery production:						
Ores, concentrates and dore	kilograms	225,000	225,000	284,000	243,000	241,000
Recycled materials (new and old scrap)	do.	144,000	153,000	163,000	152,000 r/	148,000
Imports for consumption:						
Refined	do.	64,800	147,000	141,000	130,000	96,400
Exports						
Refined	do.	141,000	174,000	257,000	658,000	334,000
Net deliveries from foreign stocks in						
Federal Reserve Bank of New York	do.	51,500	61,600	136,000	582,000	217,000
Stocks, Dec. 31:						
Industry 4/		37,100	39,400	36,700	34,400 r/	32,700
Commodity Exchange (Comex) 5/	do.	50,900	49,900	46,500	78,500	49,100
Department of the Treasury 6/	metric tons	8,150	8,150	8,150	8,140	8,140
Volume of U.S. Gold Futures Trading 7/	do.	30,300	21,200	18,700	25,500	26,400
Department of the Treasury: 8/						
American Eagle gold coin 9/	kilograms	17,400	13,700	11,100	21,800	NA
Other Numismatic gold coins	do.	695	952	965	2,250	NA
Consumption in industry and the arts	do.	118,000	114,000	110,000	91,400 r/	76,100
Apparent demands, refined 10/	do.	244,000	307,000	357,000	363,000	294,000
Price: Average per troy ounce 11/		$384.93	$363.29	$344.97	$360.91	$385.41
Employment, mine and mill only 12/		16,100	15,100	14,800	14,700	14,200
World:						
Production, mine	kilograms	2,180,000	2,190,000	2,290,000 r/	2,310,000 r/	2,290,000
Official bullion reserves 13/	metric tons	35,600	35,500 r/	35,200 r/	34,700 r/	34,500

r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ May include small quantities recovered by gravity methods.

3/ May include tailings, waste ore dumps and previously mined ore at some inactive mines.

4/ Unfabricated refined gold held by refiners, fabricators, dealers, and U.S. Department of Defense.

5/ Comex division of New York Mercantile Exchange.

6/ Includes gold in Exchange Stabilization Fund.

7 /Comex only.

8/ Sales to market fiscal year 1990; thereafter, bullion disbursements to U.S. Mint coin programs. Fiscal year begins Oct. 1, of year prior to year indicated.

9/ Sales program began Oct. 20, 1986.

10/ Defined as refinery production from primary materials + refinery production from old scrap + net bullion flow to market from foreign stocks at the New York Federal Reserve Bank + net imports of bullion. Assumed to include gold held for investment purposes. Excludes gold contained in fabricated items, imported coins, and official monetary gold.

11/ Engelhard Industries quotation.

12/ Source: Mine Safety and Health Administration.

13/ Held by central banks and governments and international monetary organizations. Source: International Monetary Fund.

TABLE 2
MINE PRODUCTION OF GOLD IN THE UNITED STATES, BY STATE 1/ 2/

(Kilograms)

State	1993	1994
Alaska	2,780 3/	5,740 4/
Arizona	2,710	1,980
California	35,800	30,100
Colorado	W	4,420
Montana 5/	14,300	12,600
Nevada	211,000	214,000
New Mexico	995	W
South Dakota	19,200	W
Washington	7,110	7,410
Other States 6/	37,300	50,100
Total	331,000	326,000

W Withheld to avoid disclosing company proprietary data; included in "Other States."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Beginning with calendar year 1994 the U.S. Bureau of Mines ceased collecting data on placer mine production. Placer mine data from other sources is footnoted.

3/ This figure, reported to the U.S. Bureau of Mines, probably understates production. Data collected by the State indicates 1993 production was 5,948 kilograms.

4/ Production data collected by the State. Data published in this table in prior years was Bureau of Mines data only; State-sourced data was appended as a footnote.

5/ In addition to reported data shown in the table, placer production was estimated by the State to have been as follows in kilograms: 1993--6; 1994--12.

6/ Includes for at least one of the years Idaho, Oregon, South Carolina, Utah, Wisconsin, and withheld placer data from other states where available.

TABLE 3
TWENTY-FIVE LEADING GOLD-PRODUCING MINES IN THE UNITED STATES IN 1994, IN ORDER OF OUTPUT

Rank	Mine	County and State	Operator	Source of gold
1	Goldstrike	Eureka, NV	Barrick Goldstrike Mines Inc.	Gold ore.
2	Carlin Mines Complex	do.	Newmont Gold Co.	Do.
3	Twin Creeks	Humboldt, NV	Santa Fe Pacific Gold Corp.	Do.
4	Bingham Canyon	Salt Lake, UT	Kennecott-Utah Copper Corp.	Copper ore.
5	Smokey Valley Common Operation	Nye, NV	Round Mountain Gold Corp.	Gold ore.
6	Homestake	Lawrence, SD	Homestake Mining Co.	Do.
7	Jerritt Canyon (Enfield Bell)	Elko, NV	Independence Mining Co. Inc.	Do.
8	Bullfrog	Nye, NV	LAC Minerals	Do.
9	McCoy and Cove	Lander, NV	Echo Bay Mining Co.	Do.
10	McLaughlin	Napa, CA	Homestake Mining Co.	Do.
11	Getchell	Humboldt, NV	FMG Inc.	Do.
12	Mesquite	Imperial, CA	Santa Fe Pacific Gold Corp.	Do.
13	Castle Mountain	San Bernardino, CA	Viceroy Gold Corp.	Do.
14	Lone Tree	Humboldt, NV	Santa Fe Pacific Gold Corp.	Do.
15	Cannon	Chelan, WA	Asamera Minerals (U.S.) Inc.	Do.
16	Denton-Rawhide	Mineral, NV	Kennecott Rawhide Mining Co.	Do.
17	Zortman-Landusky	Phillips, MT	Pegasus Gold Inc.	Do.
18	Wharf	Lawrence, SD	Wharf Resources LTD	Do.
19	Ridgeway	Fairfield, SC	Kennecott Ridgeway Mining Co.	Do.
20	Florida Canyon	Lander, NV	Pegasus Gold Inc.	Do.
21	Barney's Canyon	Salt Lake, UT	Kennecott Corp.	Do.
22	Crofoot-Lewis	Humboldt, NV	Hycroft Resources & Development Corp.	Do.
23	Mercur	Tooele, UT	Barrick Goldstrike Mines Inc.	Do.
24	Yellow Aster	Kern, CA	Glamis Gold Inc.	Do.
25	Bald Mountain	White Pine, NV	Placer Dome (U.S.) Inc.	Do.

TABLE 4
U.S. CONSUMPTION OF GOLD 1/ 2/, BY END-USE SECTOR

(Kilograms)

End use	1993	1994
Jewelry and the arts:		
Karat gold	61,700 r/	49,700
Fine gold for electroplating	373 r/	369
Gold-filled and other	3,530	3,650
Total	65,600 r/	53,700
Dental	6,170	5,430
Industrial:		
Karat gold	1,100	96
Fine gold for electroplating	9,090	9,470
Gold-filled and other	9,470	7,450
Total	19,700	17,000
Small items for investment 3/	--	--
Grand total	91,400 r/	76,100

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Gold consumed in fabricated products only; does not include monetary bullion

3/ Fabricated bars, medallions, coins, etc.

TABLE 5
U.S. EXPORTS OF GOLD, BY COUNTRY 1/ 2/

Year and country	Ores and concentrates 3/		Dore and precipitates		Refined bullion		Total		Waste and scrap	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
1993	216	$1,880	67,500	$686,000	658,000	$7,610,000	726,000	$8,300,000	66,800 4/	$616,000
1994:										
Argentina	--	--	--	--	285	3,480	285	3,480	--	--
Belgium	--	--	--	--	--	--	--	--	2,660	33,600
Brazil	--	--	--	--	255	3,120	255	3,120	--	--
Canada	414	3,390	15,500	120,000	2,900	33,200	18,800	156,000	33,600	270,000
China	--	--	9	115	636	8,000	645	8,120	--	--
France	--	--	30,300	377,000	--	--	30,300	377,000	5,020	61,700
Germany	--	--	40	141	13,200	166,000	13,300	167,000	5,580	65,400
Hong Kong	--	--	628	7,870	64,700	795,000	65,300	803,000	2	13
Ireland	--	--	--	--	793	12,000	793	12,000	5	66
Italy	--	--	3	25	12	93	15	118	351	4,330
Japan	--	--	529	6,400	1,590	19,100	2,120	25,500	90	1,370
Korea, Republic of	--	--	185	2,310	2,070	25,400	2,260	27,700	1	7
Mexico	--	--	20	251	7,940	96,100	7,960	96,300	--	--
Peru	--	--	--	--	294	3,610	294	3,610	7	89
Singapore	--	--	--	--	1,500	18,200	1,500	18,200	60	568
Sweden	--	--	--	--	--	--	--	--	998	12,600
Switzerland	--	--	9,190	113,000	95,000	1,130,000	104,000	1,240,000	7,650	64,400
Taiwan	--	--	--	--	32,500	404,000	32,500	404,000	--	--
Turkey	--	--	--	--	429	5,250	429	5,250	--	--
United Arab Emirates	--	--	--	--	707	8,690	707	8,690	--	--
United Kingdom	36	360	4,140	49,700	109,000	1,330,000	113,000	1,380,000	20,200	229,000
Other	12	29	20	158	324	3,870	356	4,060	95	1,170
Total	462	3,780	60,600	677,000	334,000	4,060,000	395,000	4,740,000	76,300	745,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Monetary gold excluded.

3/ Includes base metal ores, concentrates, and matte destined for refining.

4/ Verification of Bureau of the Census export quantities was not possible for some months of 1993. Quantities shown are rounded estimates derived by dividing dollar values, which are believed to be accurate, by an estimated value for waste and scrap of $9,400/kg.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF GOLD, BY COUNTRY 1/ 2/

Year and country	Ores and concentrates 3/ Quantity (kilograms)	Ores and concentrates 3/ Value (thousands)	Dore and precipitates Quantity (kilograms)	Dore and precipitates Value (thousands)	Refined bullion Quantity (kilograms)	Refined bullion Value (thousands)	Total Quantity (kilograms)	Total Value (thousands)	Waste and scrap Quantity (kilograms)	Waste and scrap Value (thousands)
1993	1,240	$13,500	12,500	$135,000	130,000	$1,500,000	144,000	$1,640,000	25,500	$65,400
1994:										
Argentina	--	--	--	--	117	1,560	117	1,560	1,060	15,700
Bolivia	--	--	--	--	711	8,600	711	8,600	14	101
Brazil	--	--	--	--	3,370	42,000	3,370	42,000	6	42
Canada	3	35	11,400	132,000	73,900	913,000	85,300	1,040,000	2,740	21,600
Chile	--	--	283	3,500	7,300	90,600	7,590	94,100	13	143
Colombia	--	--	67	494	1,900	20,300	1,960	20,800	14	176
Costa Rica	--	--	326	4,080	3	42	329	4,120	487	4,060
Dominican Republic	--	--	--	--	43	455	43	455	3,410	21,500
Ecuador	--	--	104	1,260	2,840	29,100	2,940	30,300	55	557
Guyana	--	--	--	--	174	2,180	174	2,180	636	7,490
Malaysia	--	--	--	--	--	--	--	--	1,350	2,150
Mexico	2,240	27,300	2,120	25,900	1,080	12,800	5,450	66,000	2,080	11,800
Panama	--	--	549	3,670	224	2,080	773	5,750	211	604
Peru	--	--	168	2,060	476	5,820	644	7,880	7,410	8,120
Philippines	--	--	--	--	--	--	--	--	736	336
Suriname	--	--	--	--	59	702	59	702	321	3,880
Switzerland	--	--	--	--	2,220	28,500	2,220	28,500	9	59
Trinidad and Tobago	--	--	--	--	17	199	17	199	538	7,330
United Kingdom	1	8	--	--	1,140	15,600	1,140	15,600	14	152
Uruguay	--	--	--	--	201	2,480	201	2,480	--	--
Venezuela	--	--	1	12	223	2,300	224	2,310	3	38
Other	--	--	113	1,160	319	3,250	432	4,400	687	5,330
Total	2,250	27,300	15,100	174,000	96,400	1,180,000	114,000	1,380,000	21,800	111,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Monetary gold excluded.

3/ Includes base metal ores, concentrates, and matte destined for refining.

Source: Bureau of the Census.

TABLE 7
GOLD: WORLD MINE PRODUCTION BY COUNTRY 1/ 2/

(Kilograms)

Country	1990	1991	1992	1993	1994 e/
Argentina	1,400 r/	1,730 r/	1,110 r/	937 r/	1,000
Armenia e/	XX	XX	500 r/	500	500
Australia	244,000	234,000	243,000 e/	247,000	256,000 3/
Belize e/	1 3/	5	5	2	2
Bolivia	5,200	3,500	4,690	10,400 r/	12,800 3/
Botswana	46	20	165	192	200
Brazil 4/	102,000	89,600 r/	85,900	74,200 r/	76,000
Burkina Faso e/	7,800	5,600	5,400	5,000	6,000
Burundi e/	9 3/	25	32	20	20
Cameroon e/	10 3/	10	10	10	10
Canada	169,000	177,000	161,000	153,000	146,000 3/
Central African Republic	241	176	155	150 e/	150
Chile	27,500	28,900	33,800	33,600 r/	38,600 3/
China e/	100,000	120,000	140,000	160,000	160,000
Colombia	29,400	34,800	32,100	27,500 r/	27,500 3/
Congo	7	12	5	5 e/	5
Costa Rica e/	460	550	550	600	650
Cote d'Ivoire	20	1,100	1,500	1,500 e/	1,500
Dominican Republic	4,350	3,160	2,380	1,500 r/ e/	1,300
Ecuador 5/	10,700	12,200	1,310 r/	940 r/	1,500 3/
Ethiopia 6/	848	3,040	2,220	3,390 r/	3,300
Fiji	4,120	2,740 r/	3,700 r/	3,780	3,440 3/
Finland	2,810	2,200	1,600	1,390 r/	1,380 3/
France	5,430 r/	4,610 r/	3,060 r/	2,160 r/ e/	3,800
French Guiana (Guyane)	870	1,420	2,140 r/	2,500 r/	2,500
Gabon 5/	80 e/	50	70	120	72
Georgia e/	XX	XX	1,500 r/	1,000 r/	600
Germany:					
Eastern states	1,750	XX	XX	XX	XX
Western states e/	18	XX	XX	XX	XX
Total	1,770	10 e/	--	--	--
Ghana	16,800	26,300	31,000	39,200	44,500 3/
Guatemala	62	31	32	30 e/	30
Guinea 7/	6,340	4,450	2,110	2,100 e/	2,100
Guyana e/	1,500	1,840	2,480	9,610	11,800 3/
Honduras	156	180	163	111 r/	106 3/
Hungary e/	600	500	500	500	200
India 8/	1,980	1,970	1,760 r/	2,000 r/	2,150
Indonesia 9/	11,200	16,900	38,000	42,100	45,000
Iran e/	500	500	500	417 3/	723 3/
Japan	7,300	8,300	8,890	9,350 r/	9,550 3/
Kazakhstan e/	XX	XX	24,000	25,000	26,000
Kenya e/	25 3/	20	20	20	20
Korea, North e/	5,000	5,000	5,000	5,000	5,000
Korea, Republic of 8/	20,800	20,800	23,300	25,000 e/	25,000
Kyrgyzstan e/	XX	XX	1,200 r/	1,500 r/	2,000
Liberia e/ 10/	600	600	700	700	--
Madagascar e/	216 3/	200	200	200	200
Malaysia	2,590	2,780	3,510	4,460	4,080 3/
Mali e/ 11/	5,200	4,900	5,700	5,500	5,500
Mexico	9,680	10,100	9,890	11,100 r/	13,900 3/
Mongolia e/	1,000	800	900	1,200 r/	2,000
Mozambique	63	394	296	149	336 3/
Namibia	1,610	1,860	2,030	1,950	2,450 3/
New Zealand	4,630	6,760	10,500	11,200 r/	12,000
Nicaragua	1,200 e/	1,150	1,320	1,240 r/	1,070 3/
Panama	85	194	250	255 e/	245
Papua New Guinea	31,900	60,800	71,200	60,600	59,300 3/
Peru 5/	9,100 e/	9,930	20,600 r/	23,100 r/	25,000 3/
Philippines	24,600	25,900	22,700	15,800	14,600 3/
Poland e/	30,000	30,000	30,000	30,000	30,000
Portugal e/	350	160	89	--	--
Romania e/	3,000	3,000	3,700	3,000	4,000
Russia	XX	XX	146,000	150,000	147,000 3/

See footnotes at end of table.

TABLE 7--Continued
GOLD: WORLD MINE PRODUCTION BY COUNTRY 1/ 2/

(Kilograms)

Country	1990	1991	1992	1993	1994 e/
Rwanda e/	2,160 3/	1,000	1,000	1,000	100
Saudi Arabia	3,540	4,780	6,150	7,520 r/	8,000
Serbia and Montenegro 12/	XX	XX	7,330	3,330	4,000
Sierra Leone 13/	32	26	92	157	123 3/
Solomon Islands e/	35	30	25	20	5
South Africa, Republic of	605,000	601,000	614,000	619,000	580,000 3/
Spain	6,810	7,400	6,580	6,080 r/	6,000
Sudan e/	100	50	1,000	1,600	2,500
Suriname e/	30	30	300	300	300
Sweden	6,330	6,250	6,160 r/	6,550 r/	6,500
Taiwan 8/	72	--	--	--	--
Tajikistan e/	XX	XX	1,700 r/	1,600 r/	1,500
Tanzania e/	3,500	4,200	6,000	6,000	6,000
Turkey e/ 14/	1,010	970	1,120	1,250	1,250
U.S.S.R. 15/	302,000	260,000	XX	XX	XX
United States	294,000	294,000	330,000	331,000	326,000 3/
Uruguay e/	--	--	--	300	300
Uzbekistan e/	XX	XX	75,000 r/	75,000 r/	75,000
Venezuela	7,700	4,220	7,550	8,710	9,940 3/
Yugoslavia 12/ 16/	8,170 r/	6,920 r/	XX	XX	XX
Zaire e/	9,300	8,800	7,000	6,000	1,080 3/
Zambia 17/	129	136	271	235 r/	210
Zimbabwe	16,900	17,800	18,300	18,900	20,500 3/
Total	2,180,000 r/	2,190,000 r/	2,290,000 r/	2,310,000 r/	2,290,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data have been rounded by the U.S. Bureau of Mines to three siginificant digits; may not add to totals shown.

2/ Table contains data available through July 20, 1995.

3/ Reported figure.

4/ Officially reported figures are as follows, in kilograms: Major companies: 1990--30,100; 1991--34,100; 1992--39,000; 1993--39,900; and 1994--45,000 (estimated). Garimpos 1990--71,800; 1991--55,500; 1992--46,800; 1993--34,300; and 1994--31,000 (estimated).

5/ Does not include undocumented production from small artisanal production.

6/ Year ending July 7 of year stated.

7/ Figures include reported Société Aurifere de Guinea (SAG) mine production of, in kilograms: 1990--1,750; 1991--1,450; 1992--1,110; and 1993--500 (estimated). Remainder represents approximate reported sales to Government, of artisanal production. Figures do not include artisanal production smuggled out of the country. In 1994, the SAG mine was closed.

8/ Refinery output.

9/ Excludes production from so-called people's mines, which may be as much as 18,000 kilograms per year, but includes gold recovered as byproduct of copper mining.

10/ These figures are based on gold taxed for export and include gold entering Liberia undocumented from Guinea and Sierra Leone.

11/ Includes estimates of artisanal production and may include some gold smuggled into Mali. The Kalana Mine accounted for about 8% in 1990; about 2% in 1991; less than 1% in 1992; and none from 1993-94. The Syama Mine began gold production in 1990 and accounted for about 42% of the total output that year, 49% in 1991; 57% in 1992; 56% in 1993; and 55% in 1994.

12/ All production in Yugoslavia from 1990-91 came from Serbia and Montenegro.

13/ Data are based on official exports and do not reflect gold moved through undocumented channels.

14/ Indicates byproduct of base metals.

15/ Dissolved in Dec. 1991.

16/ Dissolved in Apr. 1992.

17/ Year beginning Apr. 1 of year listed. Byproduct of copper production by Zambia Consolidated Ltd. only. Some addtional artisinal production was reported but data are insufficient to make a reliable estimate.

GRAPHITE

By Harold A. Taylor, Jr.

Amorphous graphite was not mined domestically in 1994. Graphite supplies again exceeded industrial demand. Prices of certain kinds of graphite dropped somewhat from those of 1993 while other kinds rose. Quoted prices mostly reflected the existing oversupply. Production of manufactured graphite and graphite fibers increased 4% and decreased 13%, respectively.

Legislation and Government Programs

No acquisitions of graphite for the strategic and critical materials stockpile occurred in 1994. *(See table 2.)*

Production

United Minerals Co. continued its suspension of production of its amorphous graphitic material from its Montana mine in 1994. Output of manufactured graphite increased 4% to about 276,000 tons, at 29 plants, with a likelihood of some unreported production for in-house use. Production of all kinds of graphite fiber and cloth decreased 13% to 3,550 tons. *(See tables 3 and 4.)*

Ucar International Inc., a graphite electrode - joint venture of Union Carbide Corp. and Mitsubishi Corp., has been revamped in ownership. Blackstone Group L.P. has assumed a 75% ownership and Union Carbide Corp. will retain a 25% ownership. This supercedes an earlier plan to sell a minority stock-holding to the public. Earnings have been under pressure in recent years from excess electrode capacity.

Domestic production data for synthetic graphite are developed by the U.S. Bureau of Mines (USBM) from a voluntary survey of domestic producers. Of the 29 operations polled, 100% responded. This represented 100% of the total production data shown in table 4. *(See table 1.)*

Consumption

Reported consumption of natural graphite decreased 5% to about 38,800 tons, according to a survey of more than 230 users. The three major uses of natural graphite were refractories, brake linings, and in packings, which together accounted for 59% of reported consumption. *(See table 5.)*

Prices

Natural graphite prices are often negotiated between the buyer and seller and are based on purity and other criteria. Therefore, published price quotations such as those in Industrial Minerals are given as a range of prices. Another source of information for graphite prices is the average customs value per ton of the different imported classes. These mainly represent shipments of unprocessed graphite. A third source for natural graphite prices is the amount paid per ton at the point of consumption.

The price for crystalline graphite at the point of consumption--mostly crystalline flake, some crystalline dust, and a little lump graphite--dropped slightly to $1,466 per ton from $1,469. The price for amorphous graphite (including small amounts of amorphous-synthetic graphite mixtures) rose slightly to $687 per ton from $683. *(See table 6.)*

Foreign Trade

Total exports of natural graphite increased 17%. Exports of graphite electrodes totaled 107,100 tons valued at $253.3 million, of which 67,500 tons ($104.4 million) went to Canada. Imports of natural graphite increased slightly from those of 1993. *(See tables 7, 8, and 9.)*

World Review

World natural graphite markets, like the domestic graphite market, were about the same as in the last several years, namely, mediocre. Domestic natural graphite consumption (apparent) backed off from 1993. Actual graphite consumption sustained a small loss. Domestic prices of imported graphite were mixed but trended upward. A Canadian producer, Victoria Graphite Inc., came on-stream while another much larger Canadian producer, the former Cal Graphite Corp., closed, for a sizable net loss in Canadian capacity. Production of graphite from kish did not advance into larger-volume production. Nothing noteworthy occurred in sales of graphite from the stockpile.

Canada.—Victoria Graphite Inc. came on-stream in mid-1994 with its new mine and plant at Portland, Ontario. The firm has the advantage of using ore running 8% to 10% graphite. The plant has a maximum capacity of 3,000 tons of flake graphite concentrate per year, and will also make expanded graphite when the necessary equipment is installed. The firm also plans to produce graphite foil in 1995, under a Japanese technology license.

Malawi.—Two South African companies have won a contract from a consortium of Malawian investors to build a graphite mine and plant at Katengeza, following a feasibility study and drilling and trenching the deposit. The South African firms, Metallurgical Design and Management (Pty.) Ltd. and Unique Engineering Ltd., also have the contract for building a new Tanzanian mine and plant at Merelani.

Namibia.—A local mining company, Roselis Mining Co., was looking for partners to explore and develop to the production stage two flake graphite deposits near Swakopmund and easily accessible to Walvis Bay. The firm's diamond drilling has shown that one of the deposits, the Tippy's, has reserves of 12 million tons averaging 6% graphite, and the other deposit, the Mary's, has reserves of 20 million tons, both amenable to open pit recovery.

Sweden.—Superior Graphite Co. will begin producing its Desulco at a 15,000 ton-capacity synthetic graphite plant at Sundsvall that was formerly operated under license from Superior by Casco Nobel.

Switzerland.—Alusuisse-Lonza Holding Ltd. has sold its synthetic graphite subsidiary, Lonza Graphites + Technologies Ltd., to Mircal, a subsidiary of the French

Imetal Group. Lonza has two plants in Switzerland that produce synthetic graphite and high-temperature lubricants. Imetal also owns 25% of Stratmin Graphite Inc., a Canadian producer of natural flake graphite.

Current Research and Technology

The USBM has demonstrated a new processing method to produce high-quality flake graphite from kish, a steelmaking waste. Kish is typically a mixture of graphite, desulfurization slag, and iron which is skimmed from the hot metal fed to the basic oxygen furnace. The graphite content of kish is estimated to be enough to meet total U.S. demand for flake graphite. The crude kish is first treated by screening and hydraulic classification, and then leached with hydrochloric acid to give a 95% graphite product with flake ranging from 10 mesh down.[1]

Outlook

Projected demand for crystalline flake graphite totaled 27,000 tons for 1995 and 32,000 tons for the year 2000. Demand for other graphite, mostly amorphous, totaled 15,000 tons for 1995 and 13,000 tons for the year 2000. This very slow growth rate reflects the maturity of the market, mostly in refractories, and particularly in carbon-magnesite brick. Production capacity is unlikely to increase from the present level while the overcapacity exists.

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[1] Laverty, P. D., L. J. Nicks, and L. A. Walters. Recovery of Flake Graphite from Steelmaking Kish. BuMines RI 9512, 1994, 23 pp.

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Wall Street Journal.

TABLE 1
SALIENT NATURAL GRAPHITE STATISTICS 1/

		1990	1991	1992	1993	1994
United States:						
Production	metric tons	--	--	--	--	--
Apparent consumption 2/	do.	38,700	14,200	29,500	34,800	32,900
Exports	do.	11,500	19,400	20,200	17,400	20,300
Value	thousands	$9,480	$11,300	$12,200	$11,100	$13,100
Imports for consumption	metric tons	50,200	33,500	49,700	52,200	53,100
Value	thousands	$35,200	$21,700	$25,500	$29,900	$26,900
World: Production	metric tons	946,000 r/	771,000	745,000 r/	731,000 r/	719,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Domestic production plus imports minus exports.

TABLE 2
U.S. GOVERNMENT STOCKPILE GOALS AND YEAREND STOCKS OF NATURAL GRAPHITE IN 1994, BY TYPE

(Metric tons)

Type	Goal	National stockpile inventory
Madagascar crystalline flake	(1/)	15,200
Sri Lanka amorphous lump	12,200	4,930
Crystalline, other than Madagascar and Sri Lanka	(1/)	1,750
Nonstockpile-grade, all types	(1/)	846

1/ This commodity no longer has a goal.

Source: Defense National Stockpile Center, Inventory of Stockpile Materials as of Dec. 31, 1994.

TABLE 3
PRINCIPAL PRODUCERS OF SYNTHETIC GRAPHITE IN 1994

Company	Plant location	Product 1/
Amoco Performance Products Co.	Greenville, SC	Cloth, high modulus fibers.
Ashland Petroleum	Ashland, KY	High modulus fibers.
Black Diamond Graphite, Metallics Systems Div.	Sanborn, NY	Unmachined shapes.
Carbone of America	St. Marys, PA	Motor brushes; unmachined shapes; other.
Fiber Materials, Inc.	Biddeford, ME	Other.
Fiber Technology Corp.	Provo, UT	--
Fortafil Fibers Inc.	Rockwood, TN	High modulus fibers.
B F Goodrich Co., Engineered Systems Div., Super Temp Operations	Santa Fe Springs, CA	Other.
Grafil Inc.	Sacramento, CA	High modulus fibers.
Hercules Inc.	Salt Lake City, UT	Do.
HITCO Materials Group, B P Chemicals Ltd.	Gardena, CA	Cloth.
Minerals Technology, Inc.; Specialty Minerals Corp.	Easton, PA	Other.
National Electrical Carbon Co.	Fostoria, OH	Unmachined shapes; high modulus fibers.
NAC Carbon Products, Inc.	Punxsutawney, PA	Other.
Polycarbon, Inc.	Valencia, CA	Cloth.
Showa Denko Carbon Inc.	Ridgeville, SC	Electrodes; other.
SGL Carbon Corp.	Hickman, KY	Anodes; crucibles; electrodes; unmachined shapes; other.
Do.	Morganton, NC	Do.
Do.	Niagara Falls, NY	Do.
Do.	Ozark, AR	Do.
Superior Graphite Co.	Russellville, AR	Electrodes.
Do.	Hopkinsville, KY	Other.
Textron Specialty Materials	Lowell, MA	High modulus fibers.
The Carbide/Graphite Group, Inc.; Graphite Specialties	Niagara Falls, NY	Anodes; crucibles; motor brushes; electrodes; unmachined shapes; refractories; other.
Do.	St. Marys, PA	Do.
UCAR Carbon Company, Inc.	Clarksburg, WV	Anodes; electrodes; unmachined shapes; other.
Do.	Clarksville, TN	Do.
Do.	Columbia, TN	Do.
Zoltek Corp.	St. Charles, MO	High modulus fibers.

1/ Cloth includes low-modulus fibers; motor brushes include machined shapes; crucibles includes vessels.

TABLE 4
U.S. PRODUCTION OF SYNTHETIC GRAPHITE, BY END USE 1/

End use	1993 Quantity (metric tons)	1993 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Anodes 2/	W	W	W	W
Cloth and fibers (low-modulus)	37	$4,540	62	$5,170
Crucibles and vessels and refractories 2/	W	W	W	W
Electric motor brushes and machined shapes	2,510 r/	18,700	W	W
Electrodes	172,000 r/	411,000 r/	177,000	467,000
Graphite articles 3/	--	38,700	--	41,200
High-modulus fibers	4,050	158,000	3,490	126,000
Unmachined graphite shapes	4,240	27,600	8,780	42,100
Other	13,300 r/	50,500 r/	20,400	78,000
Total	196,000 r/	709,000 r/	209,000	759,000
Synthetic graphite powder and scrap 4/	69,100	36,400	66,600	34,600
Grand total	265,000 r/	745,000 r/	276,000	794,000

r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Anodes, crucibles/vessels and refractories end products are included in the "Other" products category.

3/ Includes all items for which quantity data are usually unavailable.

4/ Includes lubricants (alone/in greases), steelmaking carbonraisers, additives in metallurgy, and other powder data.

TABLE 5
U.S. CONSUMPTION OF NATURAL GRAPHITE, BY USE 1/

End use	Crystalline		Amorphous 2/		Total	
	Quantity (thousands)	Value (thousands)	Quantity (thousands)	Value (thousands)	Quantity (thousands)	Value (thousands)
1992:	24,300	$35,900	17,500	$11,800	41,800	$47,800
1993:						
Batteries	W	W	W	W	606	1,410
Brake linings	1,670	2,270	5,050	4,210	6,720	6,480
Carbon products 3/	561	1,620	493	331	1,050	1,950
Crucibles, retorts, stoppers, sleeves and nozzles.	W	W	W	W	995	1,020
Foundries 4/	720	840	2,220	1,210	2,940	2,050
Lubricant group:						
Lubricants	708	1,230	2,430	1,560	3,140	2,790
Packing; other 5/	4,220	6,050	86	134	4,310	6,180
Pencils	2,560	2,950	236	169	2,800	3,120
Powdered metals	2,000	4,120	372	302	2,370	4,430
Refractories	7,750	8,730	2,730	757	10,500	9,490
Rubber	189	287	424	375	613	662
Steelmaking	W	W	W	W	1,720	1,030
Other 6/	1,460	4,160	1,650	1,470	3,110	5,630
Withheld uses	1,460	1,980	1,860	1,480	--	--
Total	23,300	34,200	17,600	12,000	40,900	46,200
1994:						
Batteries	455	1,110	140	438	595	1,550
Brake linings	2,580	3,010	5,710	4,650	8,290	7,600
Carbon products 3/	660	1,890	490	384	1,150	2,270
Crucibles, retorts, stoppers, sleeves and nozzles.	1,020	956	6	10	1,030	966
Foundries 4/	659	697	1,500	783	2,160	1,480
Lubricant group:						
Lubricants	568	1,110	1,670	1,080	2,350	2,080
Packing; other 5/	4,860	6,100	119	193	4,980	6,290
Pencils	1,520	1,650	167	104	1,690	1,750
Powdered metals	1,840	3,930	51	101	1,890	4,030
Refractories	6,730	8,100	2,890	774	9,620	8,880
Rubber	156	397	703	542	859	939
Steelmaking	47	796	1,130	674	1,180	1,470
Other 6/	984	2,660	2,070	1,670	3,060	4,330
Withheld uses	--	--	--	--	--	--
Total	22,100	32,400	16,600	11,400	38,800	43,600

W Withheld to avoid disclosing company proprietary data; included with "Withheld uses" and "Total" where applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes mixtures of natural and manufactured graphite.

3/ Includes bearings and carbon brushes.

4/ Includes foundries (other) and foundry facings.

5/ Includes packings; ammunition; and seed coating.

6/ Includes paints and polishes; small packages; antiknock and other compounds; soldering/welding; mechanical products; electrical/electronic devices; industrial diamonds; drilling mud; magnetic tape; and other end-use categories.

TABLE 6
REPRESENTATIVE YEAREND GRAPHITE PRICES

(Per metric ton)

Type	1993	1994
Industrial minerals: 1/ 2/		
Crystalline large flake, 85% to 90% carbon	$400 - $600	$400 - $600
Crystalline medium flake, 85% to 90% carbon	300 - 500	300 - 500
Crystalline small flake, 80% to 90% carbon	250 - 500	250 - 500
Amorphous powder, 80% to 85% carbon	220 - 440	220 - 300
Custom value, at foreign ports: 3/		
Flake	612 r/	629
Lump and chip, Sri Lankan	789	709
Amorphous, Mexican	127	138

r/ Revised.

1/ Prices are normally "Cost, insurance, and freight" (C.i.f.) main European port.

2/ Source: "Industrial Minerals;" No. 315, Dec. 1993, p. 54 and No. 327, Dec. 1994, p. 62.

3/ Source: Department of Commerce, Bureau of the Census, adjusted by the U.S. Bureau of Mines.

TABLE 7
U.S. EXPORTS OF NATURAL AND ARTIFICIAL GRAPHITE , BY COUNTRY 1/ 2/

Country	Natural 3/		Artificial 4/		Total	
	Quantity (Metric tons)	Value 5/	Quantity (Metric tons)	Value 5/	Quantity (Metric tons)	Value 5/
1993:						
Canada	3,880	$2,515,000	13,800	$5,944,000	17,700	$8,459,000
Japan	275	429,000	3,260	6,240,000	3,530	6,670,000
Korea, Republic of	38	42,000	4,500	2,840,000	4,540	2,880,000
Mexico	7,450	2,770,000	742	488,000	8,190	3,250,000
Other	5,710 r/	5,400,000 r/	12,700 r/	15,300,000 r/	14,600	16,000,000
Total	17,400	11,100,000	35,000	30,900,000	52,400	42,000,000
1994:						
Canada	4,060	2,610,000	6,520	9,340,000	10,600	11,900,000
Japan	428	483,000	8,130	4,460,000	8,560	4,940,000
Korea, Republic of	94	134,000	5,050	2,700,000	5,140	2,840,000
Mexico	6,650	2,710,000	1,620	889,000	8,270	3,600,000
Other	9,020	7,140,000	16,500	22,100,000	25,500	29,200,000
Total	20,300	13,100,000	37,800	39,500,000	58,100	52,500,000

r/ Revised.

1/ Previously published and 1994 data are rounded to three significant digits; may not add to totals shown.

2/ Numerous countries for which data were reported have been combined within the "Other" category under the "Country" list.

3/ Amorphous, crystalline flake, lump and chip and natural, not elsewhere classified. The applicable "Harmonized Tariff Schedule" (HTS) nomenclature title and code(s) are: "Natural graphite in powder or in flakes"/"Other;" HTS Nos. 2504.10/90.0000.

4/ Includes data from the applicable "Harmonized Tariff Schedule" (HTS) nomenclatures: "Artificial graphite" and "Colloidal or semicolloidal graphite;" their respective HTS code Nos. are 3801.10/.20.0000.

5/ Values are F.a.s..

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF NATURAL GRAPHITE, BY COUNTRY 1/ 2/

Country or territory	Crystalline flake and flake dust		Lump and chippy dust		Other natural crude; high-purity; expandable.		Amorphous		Total	
	Quantity (metric tons)	Value 3/ (thousands)	Quantity (metric tons)	Value 3/ (thousands)	Quantity (metric tons)	Value 3/ (thousands)	Quantity (metric tons)	Value 3/ (thousands)	Quantity (metric tons)	Value 3/ (thousands)
1992	21,100 r/ 4/	$14,020 r/ 4/	492	$528	12,500 r/ 5/	$8,760 r/ 5/	15,700	$2,230	49,700	$25,500
1993:										
Australia	1	6	--	--	--	--	--	--	1	6
Austria	--	--	--	--	--	--	20	10	20	10
Brazil	(6/)	(6/)	--	--	3,280 r/	4,530 r/	--	--	3,280	4,530
Canada	16,900 r/	10,000 r/	--	--	961 r/	407 r/	--	--	17,900	10,400
China	616 r/	380 r/	--	--	8,690 r/	3,760 r/	91	14	9,390	4,150
France	76	182	--	--	57	435	--	--	133	617
Germany	(6/)	(6/)	--	--	157 r/	1,860 r/	--	--	157	1,860
Hong Kong	--	--	--	--	--	--	385	61	385	61
India	21	10	--	--	199	279	--	--	220	288
Japan	--	--	--	--	333	1,660	--	--	333	1,660
Madagascar	3,350 r/	2,370 r/	--	--	(6/)	(6/)	--	--	3,350	2,370
Mexico	--	--	--	--	387	162	13,700	1,730	14,100	1,890
Mozambique	--	--	--	--	--	--	--	--	--	--
Norway	56	23	--	--	--	--	--	--	56	23
South Africa, Republic of	74	111	--	--	--	--	--	--	74	111
Sri Lanka	--	--	712	562	--	--	--	--	712	562
Switzerland	(7/)	7	--	--	10	117	--	--	11	124
Ukraine	--	--	--	--	16	60	--	--	16	60
United Kingdom	101	123	--	--	20	10	--	--	121	134
Zimbabwe	1,740 r/	851 r/	--	--	(6/)	(6/)	--	--	1,740	851
Other 8/	214 r/	107 r/	--	--	(7/)	14	--	--	214 r/	121 r/
Total	23,200 r/	14,200 r/	712	562	14,100 r/	13,300 r/	14,200	1,820	52,200	29,900
1994:										
Australia	324	84	--	--	--	--	--	--	324	84
Austria	--	--	--	--	--	--	20	12	20	12
Brazil	--	--	--	--	3,050	4,210	--	--	3,050	4,210
Canada	14,400	9,120	--	--	622	241	--	--	15,000	9,360
China	823	306	--	--	8,070	2,490	2,400	250	11,300	3,050
France	146	154	--	--	105	802	--	--	252	955
Germany	--	--	--	--	127	373	--	--	127	373
Hong Kong	--	--	--	--	--	--	144	22	144	22
India	17	29	--	--	220	257	--	--	237	286
Japan	--	--	--	--	256	1,590	--	--	256	1,590
Madagascar	3,710	2,650	--	--	--	--	--	--	3,710	2,650
Mexico	--	--	--	--	321	257	15,800	2,170	16,100	2,430
Mozambique	--	--	--	--	62	51	--	--	62	51
Norway	17	7	--	--	93	35	--	--	110	42
South Africa, Republic of	18	34	--	--	31	241	--	--	49	275
Sri Lanka	--	--	718	509	--	--	--	--	718	509
Switzerland	--	--	--	--	54	71	--	--	54	71
Ukraine	--	--	--	--	--	--	--	--	--	--
United Kingdom	27	99	--	--	4	32	--	--	31	132
Zimbabwe	580	354	--	--	--	--	--	--	580	354
Other 8/	1,020	399	--	--	(7/)	13	--	--	1,020	412
Total	21,000	13,200	718	509	13,000	10,700	18,400	2,460	53,100	26,900

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The information framework from which data for this material were derived originated from Harmonized Tariff Schedule (HTS) base data.

3/ Customs values.

4/ Revisions include Canada, 16,100 tons valued at $10,000,000 ; China, 373 tons valued at $241,000; Madagascar, 3,350 tons valued at $2,730,000; and Zimbabwe, 994 tons valued at $760,000. Brazil, Germany, and Japan are revised to zero.

5/ Revisions include Brazil, 1,620 tons valued at $2,510,000; Canada, 516 tons valued at $215,000; China, 6,420 tons valued at $3,430,000; Germany, 64 tons valued at $250,000; and Japan, 3,190 tons valued at $1,410,000. Madagascar and Zimbabwe data are revised to zero.

6/ Revised to zero.

7/ Less than 1/2 unit.

8/ Includes Armenia (1993), Belgium (1993), Israel (1993), Italy (1993), Namibia (1993), Poland and Taiwan.

Source: Bureau of the Census, adjusted by the U.S. Bureau of Mines.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF GRAPHITE ELECTRODES, BY COUNTRY 1/ 2/

Country	Quantity 3/ (metric tons)	Value 4/ (thousands)
1993:		
Canada	5,410	$8,320
Germany	2,180	5,890
Italy	5,730	9,010
Japan	6,370	12,200
Mexico	10,500	15,400
Other r/	3,790	9,610
Total	34,000	57,800
1994:		
Canada	11,900	28,400
Germany	2,950	8,400
Italy	6,260	10,000
Japan	7,840	20,600
Mexico	10,200	14,700
Other	6,490	12,800
Total	45,700	95,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The applicable "Harmonized Tariff Schedule" (HTS) code and nomenclature title are: (HTS 8545.11.0000); "Electric Furnace Electrodes."

3/ For both 1993 and 1994, for countries reflecting less than 1,000 metric tons each for yearly imports, data have been combined under the "Other" category in the "Country" list.

4/ Customs values.

Source: Bureau of the Census.

TABLE 10
GRAPHITE: WORLD PRODUCTION, BY COUNTRY 1/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Argentina	318 r/	85 r/	20 r/	20 r/ e/	25
Austria	22,705	19,750	19,796 r/	4,146 r/	--
Brazil (marketable) 2/	28,890	26,965	29,414	29,472 r/	29,000
Burma 3/	45	36	--	--	--
Canada (exports of natural graphite)	10,200	6,200	17,400	18,700 r/	15,800
China e/	455,000	289,000	300,000	310,000	320,000
Czech Republic	XX	XX	XX	27,000 r/	25,000
Czechoslovakia 4/	39,000	47,000	20,000 e/	XX	XX
Germany	19,314	15,807	11,963	8,363 r/	8,000
India (run-of-mine) 5/	61,000	69,922	72,996 r/	74,724 r/	75,000
Korea, North e/	35,000	35,000	38,000	38,000	38,000
Korea, Republic of:					
Amorphous	98,987	75,239	75,000 e/	72,000 e/	72,000
Crystalline flake	703	1,552	8,412	5,912 r/	6,000
Madagascar	18,036	14,079	8,910	8,000 e/	8,000
Mexico:					
Amorphous	22,553	35,315	30,500 r/	42,600 r/	43,000
Crystalline flake	2,365	1,943	985	960 r/	1,000
Namibia e/	--	200	200	-- r/	--
Norway e/	5,000	6,930 6/	7,000 r/	6,500 r/	6,000
Romania e/	6,000	6,000	2,300 6/	2,000	2,070 6/
Russia e/	XX	XX	15,000	10,000	8,000
Sri Lanka	5,469	6,381	3,307	5,163 r/	5,000
Turkey (run-of-mine) 7/	18,712	25,867	20,978	20,000 e/	20,000
Ukraine e/	XX	XX	50,000	40,000	30,000
U.S.S.R. e/ 8/	80,000	75,000	XX	XX	XX
Zimbabwe	16,383	12,903	12,346	7,142 r/	7,200
Total	945,680 r/	771,174 r/	744,527 r/	730,702 r/	719,095

e/ Estimated. r/ Revised. XX Not applicable.

1/ Table includes data available through May 18, 1995.

2/ Does not include the following quantities sold directly without beneficiation, in metric tons: 1990--8,400; 1991--7,298; 1992--8,957; 1993--9,960 (revised); and 1994--10,000 (estimated).

3/ Data are for fiscal years beginning Apr. 1 of that stated.

4/ Dissolved Dec. 31, 1992. All production in Czechoslovakia from 1990-92 came from what is now the Czech Republic.

5/ Indian marketable production is 10% to 20% of run-of-mine production.

6/ Reported figure.

7/ Turkish marketable production averages approximately 5% of run-of-mine production. Almost all is for domestic consumption.

8/ Dissolved in Dec. 1991.

GYPSUM

By Gordon T. Austin

Public Law 100-418 requires U.S. Government agencies to implement the use of metric units in their business activities. The U.S. Bureau of Mines (USBM), to be in compliance with the law, has developed a schedule for making an orderly transition from English to metric units when reporting gypsum statistics in the Annual Report.

For the 1994 Annual Report, weight data will be reported in metric units only. All other data; e.g., wallboard area; will continue to be reported in English units.

For the 1995 Annual Report, all data will be reported in metric units.

Demand for gypsum products increased in 1994, a result of increased construction activity. The quantity of crude gypsum mined, calcined gypsum produced, and wallboard products shipped was greater than that in 1993.

Sales of gypsum products increased 12% to 27 million metric tons, and value increased 48% to $2.6 billion. Increased demand caused higher prices for gypsum products. Total value of gypsum product exports decreased 4% to $75 million.

Production

The United States remained the world's leading producer of gypsum, accounting for 17% of the total world output. *(See table 8.)* Crude gypsum was mined by 31 companies at 59 mines in 19 States. Production increased 9%. Leading producing States, in descending order, were Oklahoma, Iowa, Texas, Michigan, Nevada, California, and Indiana. These seven States produced more than 1 million tons each and together accounted for 75% of total domestic production. Leading companies were USG Corp., 11 mines; National Gypsum Co., 7 mines; Georgia-Pacific Corp., 7 mines; Harrison Gypsum Inc., 3 mines; and Temple-Inland Forest Products Corp., 1 mine. These 5 companies, operating 29 mines, produced 66% of the total crude gypsum.

Leading individual mines, in descending order of production, were Harrison's Cement #2 Mine, Caddo County, OK; USG's Plaster City Mine, Imperial County, CA; USG's Sweetwater Mine, Nolan County, TX; USG's Sperry Mine, Des Moines County, IA; USG's Shoals Mine, Martin County, IN; USG's Alabaster Mine, Iosco County, MI; National's Tawas Mine, Iosco County, MI; Temple-Inland's Fletcher Mine, Comanche County, OK; Briar's Briar Mine, Howard County, AR; and National's Sun City Mine, Barber County, KS. These 10 mines accounted for 41% of the national total. Average output for the 59 active mines increased 7% to 292,000 tons.

Gypsum was calcined by 13 companies at 69 plants in 28 States, principally for the manufacture of gypsum wallboard and plaster. Calcined output increased 10% in tonnage and decreased 16% in value. Leading States, in descending order, were Iowa, California, Texas, Florida, Nevada, and New York. These 6 States, with 27 plants, accounted for 47% of the national output.

Leading companies were USG, 20 plants; National Gypsum, 18 plants; Georgia-Pacific, 10 plants; Domtar, 6 plants; and Temple Inland and Celotex, with 2 plants each. These 6 companies, operating 56 plants, accounted for 79% of the national output.

Leading individual plants were, in descending order of production, USG's Plaster City plant, Imperial County, CA; USG's Jacksonville plant, Duval County, FL; USG's Sweetwater plant, Nolan County, TX; USG's Sperry plant, Des Moines County, IA; USG's Shoals plant, Martin County, IN; National's Tampa plant, Hillsborough County, FL; USG's Baltimore plant, Baltimore County, MD; GA Pacific's ACME plant, Hardeman County, TX; Centex's Bernalillo plant, Sandoval County, NM; and Temple-Inlands Fletcher plant, Comanche County, OK. These 10 plants counted for 29% of the national production. Average calcine production for the 69 U.S. plants was 242,000 tons, 11% more than that in 1993.

A total of 950,000 tons of byproduct gypsum, valued at $4.2 million, was used, principally in agriculture but some for gypsum wallboard manufacturing. Approximately 89% was of nonphosphogypsum origin compared with 90% in 1992.

According to the Gypsum Association, yearend gypsum wallboard plant capacity for producing 1/2-inch regular wallboard increased slightly to 25.2 billion square feet per year. Total wallboard shipments were 23.2 billion square feet, 92% of capacity. Domtar's plants at Florence, CO, and at Sweetwater, TX, remained closed throughout the year. The Gypsum Association in the United States, of which all Canadian wallboard producers were members, reported that yearend capacity for 1/2-inch regular wallboard in Canada was 3.71 billion square feet, slightly more than the 1993 yearend capacity. *(See tables 2 and 3.)*

Domestic production data for gypsum are developed by the USBM from a survey of U.S. gypsum operations. Of the 117 operations to which the annual survey request was sent, 107 responded, representing 91% of the total crude gypsum production shown in tables 1 and 2. Nonrespondents were estimated from monthly and quarterly canvasses or from previous years' data. *(See table 1.)*

Consumption

Apparent consumption, defined as production plus net imports plus industry stock changes, of crude gypsum, including byproduct gypsum, increased 9% to 26.2 million tons. Net imports provided 32% of the crude gypsum consumed. Apparent consumption of calcined gypsum increased 10% to 16.7 million tons.

Yearend stocks of crude gypsum at mines and calcining plants were 2.6 million tons.

Of the total gypsum products sold or used, about 27% was uncalcined. Uncalcined gypsum, crushed and screened to specifications, is marketed for use in portland cement manufacture, agriculture, and fillers. The cement industry uses gypsum to retard the setting time of concrete.

Finely ground gypsum rock is used in agriculture to neutralize alkaline and saline soils, improve the permeability of argillaceous materials, and provide sulfur and catalytic support for maximum fertilizer utilization and leguminous productivity. Small amounts of very pure gypsum are used as fillers and in glassmaking, papermaking, and pharmaceutical applications. In 1994, 65% of the uncalcined gypsum was used in portland cement and the remainder was used mainly for agricultural purposes.

Of the total calcined gypsum products, most went into prefabricated products. A small percentage was used in industrial and building plasters. Of the prefabricated products, based on surface square feet, 63% was regular wallboard; 24% was fire-resistant type X wallboard; 5% was 5/16-inch mobile home board; and 3% was water- and/or moisture-resistant board. Lath, veneer base, sheathing, predecorated, and other types made up the balance. Of the regular wallboard, 82% was 1/2-inch and 10% was 5/8-inch.

In descending order, the leading sales regions for prefabricated products were the South Atlantic, East North Central, Pacific, and West South Central. *(See tables 4 and 5.)*

Markets and Prices

On an average value-per-ton basis, f.o.b. mine or plant, crude gypsum decreased slightly to $6.70, calcined gypsum decreased 4% to $17.23, and byproduct gypsum increased 9% to $4.39. Prefabricated products were valued at $127.77 per ton, plasters at $159.77 per ton, and uncalcined products at $12.12 per ton.

Quoted prices for gypsum wallboard products were published monthly in Engineering News Record. Spot prices in December, based on truck lots delivered to the job, showed a wide range. Regular 1/2-inch wallboard prices ranged from $93 per thousand square feet at Cincinnati to $190 at Detroit. The average price in December for 20 cities was $149 per thousand square feet, with some minor discounts for prompt payment. This represented a 15% increase compared with that of December 1993.[1]

Foreign Trade

Imports for consumption of crude gypsum increased 15% to 8.5 million tons. Net imports represented 31% of apparent consumption. Crude gypsum from Canada and Mexico was used mainly to feed wallboard plants in coastal cities. Imports from Spain, the other major source of imported gypsum, were used mostly for portland cement manufacture. *(See tables 6 and 7.)*

World Review

Estimated world production of crude gypsum increased slightly to 101 million tons. Total world production figures are probably low because, in some countries, significant production was consumed captively and not reported. Also, production from small deposits in developing countries was intermittent and often unreported. The United States remained the world's largest producer of crude gypsum with 17% of the world total. *(See table 8.)*

Outlook

More than 90% of the gypsum consume annually in the United States is used i construction, mainly in gypsum wallboar products, building plasters, and th manufacture of portland cement. The declin in construction activity that depresse demand for gypsum products over the pas several years appears to have ended Gypsum product demand recovered in 1992 1993, and 1994, although not to the recor highs of 1989. A slow but steady recover is expected to continue over the next fe years.

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[1] Engineering News Record. Dec. 19, 1994, p 63.

OTHER SOURCES OF INFORMATION

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Pit and Quarry.
Rock Products.

TABLE 1
SALIENT GYPSUM STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Active mines and plants 2/	106	112	109	112	108
Crude:					
Mined	14,900	14,000	14,800	15,800	17,200
Value	$99,600	$94,200	$101,000	$107,000	$115,000
Imports for consumption	7,920	6,930	7,180	7,390	8,470
Byproduct gypsum sales	667	618	630	846	950
Calcined:					
Produced	15,900	13,900	15,100	15,200	16,700
Value	$279,000	$241,000	$250,000	$272,000	$228,000
Products sold (value)	$1,710,000 3/	$1,350,000 3/	$1,348,648 3/	$1,780,000	$2,630,000
Exports (value)	$84,500	$85,600	$97,000	$77,600	$73,400
Imports for consumption (value)	$110,000	$88,100	$96,000	$111,000	$141,000
World: Production	104,000	100,000	100,000 r/	99,400 r/	101,000 e/

e/ Estimated. r/ Revised.

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Each mine, calcining plant, or combination mine and plant is counted as one establishment; includes plants that sold byproduct gypsum.

3/ Does not include value of plasters sold.

TABLE 2
CRUDE GYPSUM MINED IN THE UNITED STATES, BY STATE 1/

State	1993			1994		
	Active mines	Quantity (thousand metric tons)	Value (thousands)	Active mines	Quantity (thousand metric tons)	Value (thousands)
Arizona and New Mexico	6	791	$6,210	6	997	$7,540
Arkansas, Kansas, Louisiana	5	1,430	11,100	5	1,550	11,800
California, Nevada, Utah	12	2,900	15,700	12	3,080	16,600
Colorado, South Dakota, Wyoming	6	707	5,010	5	737	5,260
Indiana, New York, Ohio, Virginia	5	1,900	16,500	5	2,020	18,600
Iowa	6	1,990	12,300	6	2,210	12,700
Michigan	5	1,690	14,200	5	1,790	15,300
Oklahoma	8	2,650	15,400	9	2,890	17,000
Texas	5	1,760	10,100	6	1,870	10,100
Total	58	15,800	107,000	59	17,200	115,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 3
CALCINED GYPSUM PRODUCED IN THE UNITED STATES, BY STATE 1/

State	1993			1994		
	Active plants	Quantity (thousand metric tons)	Value (thousands)	Active plants	Quantity (thousand metric tons)	Value (thousands)
Arizona, Colorado, New Mexico, Utah	5	836	$6,840	5	1,050	$6,270
Arkansas, Louisiana, Oklahoma	7	1,320	21,200	7	1,910	27,700
California	6	1,520	27,000	5	1,420	23,800
Delaware, Maryland, North Carolina, Virginia	6	1,480	32,200	6	1,510	32,700
Florida	3	1,150	25,700	3	1,210	29,400
Georgia	3	506	8,580	3	513	8,780
Illinios, Indiana, Kansas	6	1,310	21,900	6	1,380	23,300
Iowa	5	1,350	20,300	5	1,520	23,500
Massachusetts, New Hampshire, New Jersey	5	914	19,900	5	997	21,400
Michigan	4	586	12,300	4	598	13,500
Nevada	4	1,030	15,300	4	1,190	15,100
New York	4	1,010	22,400	4	998	17,600
Ohio	3	375	7,780	3	440	9,280
Texas	5	1,210	18,700	6	1,490	24,000
Washington and Wyoming	4	654	12,200	3	516	9,910
Total	70	15,200	272,000	69	16,700	288,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 4
GYPSUM PRODUCTS (MADE FROM DOMESTIC, IMPORTED, AND BYPRODUCT GYPSUM) SOLD OR USED IN THE UNITED STATES, BY USE 1/

(Thousands metric tons and thousand dollars)

Use	1993		1994	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland cement	3,290	37,700	4,750	54,200
Agriculture and miscellaneous 2/	2,270	34,500	2,520	33,700
Total	5,560	72,300	7,260	88,000
Calcined:				
Plasters	703	94,900	553	88,400
Prefabricated products 3/	18,000	1,610,000	19,200	2,450,000
Total calcined	18,700	1,710,000	19,700	2,540,000
Grand total	24,200	1,780,000	27,000	2,630,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes byproduct gypsum.

3/ Includes weight of paper, metal, or other materials and some byproduct gypsum.

TABLE 5
PREFABRICATED GYPSUM PRODUCTS SOLD OR USED IN THE UNITED STATES 1/

Product	1993			1994		
	Thousand square feet	Thousand metric tons 2/	Value (thousands)	Thousand square feet	Thousand metric tons 2/	Value (thousands)
Lath:						
3/8 inch	8,867	6	$1,606	6,886	4	$1,410
1/2 inch	193	(3/)	30	137	(3/)	24
Other	5,867	5	407	5,867	5	407
Total	14,927	11	2,044	12,890	10	1,841
Veneer base	405,815	369	31,929	419,149	374	36,667
Sheathing	218,901	194	24,731	286,166	242	33,544
Regular gypsumboard:						
3/8 inch	778,869	604	62,153	918,125	711	69,102
1/2 inch	11,180,478	8,986	770,285	11,885,323	9,357	1,487,447
5/8 inch	1,567,859	1,360	68,185	1,466,834	1,225	57,282
1 inch	172,342	165	32,225	172,079	155	31,905
Other 4/	124,062	98	16,611	128,872	101	16,470
Total	13,823,610	11,213	949,460	14,571,233	11,548	1,662,206
Type X gypsumboard	4,960,743	4,700	381,882	5,526,219	5,157	460,985
Predecorated wallboard	90,468	81	27,064	87,066	78	27,872
5/16-inch mobile home board	1,161,521	780	103,847	1,226,687	843	117,345
Water-/moisture-resistant board	610,398	528	71,261	658,432	558	84,529
Other	117,347	104	21,366	407,790	382	27,168
Grand total	21,403,730	17,979	1,613,583	23,195,632	19,192,116	2,452,158

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes weight of paper, metal, or other materials.

3/ Less than 1/2 unit.

4/ Includes 1/4, 7/16, and 3/4-inch gypsumboard.

TABLE 6
IMPORTS FOR CONSUMPTION OF CRUDE GYPSUM, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	Value	Quantity	Value
Australia	30	239	28	231
Bahamas, The	69	429	218	1,160
Canada 2/	5,210	44,600	5,900	45,600
China	2	227	(3/)	2
Dominican Republic	(3/)	11	(3/)	10
France	(3/)	8	-	-
Germany	(3/)	3	(3/)	2
India	-	-	(3/)	10
Jamaica	76	584	73	603
Japan	(3/)	9	(3/)	42
Mexico	1,670	9,260	1,990	11,600
Spain	339	2,810	264	2,060
United Kingdom	1	76	1	97
Total	7,390	58,200	8,470	61,400

1/ Previously published and 1994 data are roundded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes anhydrite.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 7
SUMMATION OF U.S. GYPSUM AND GYPSUM PRODUCTS TRADE DATA 1/

(Thousand metric tons and thousands dollars)

Year	Crude 2/		Plasters 3/		Boards 4/		Other 5/	Total
	Quantity	Value	Quantity	Value	Quantity	Value	Value	Value
Exports:								
1993	69	3,640	156	21,200	91	24,600	28,200	77,600
1994	89	4,090	153	22,600	74	19,600	26,700	73,400
Imports for consumption:								
1993	7,390	58,200	23	1,670	171	16,200	34,900	111,000
1994	8,470	61,400	5	980	370	39,700	39,300	141,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to threa significant digits; may not add to totals shown.

2/ Import and export data are for "Gypsum; anhydrite, " Harmonized Tariff Schedule 2520.10.0000.

3/ Import and export data are for "Plasters, " Harmonized Tariff Schedule 2520.20.0000.

4/ Import and export data are for " Boards, sheets, panels, tiles and similar articles, not omamanted: Faced or reinforced with paper or paperboard only," Harmonized Tariff Schedule 6809.11.0000.

5/ Import and export data are for "Boards, sheets, panels, tiles, and similar articles, not omamanted: other, " Harmonized Tariff Schedule 6809.19.000 and "Other articles," Harmonized Tariff Schedule 6809.90.0000.

Source: Bureau of the Census.

TABLE 8
GYPSUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Algeria e/	250	152	150	150	150
Angola e/	57	57	57	50	50
Argentina	616	384 r/	514 r/	519 r/	520
Australia e/	1,800	2,000	2,000	2,000	2,000
Austria 3/	752 r/	655	792	876 r/	1,070 4/
Azerbaijan e/	XX	XX	100	75	60
Brazil 3/	824	967	888 r/	809 r/	876
Bulgaria 3/	494	63	125 r/	100 r/ e/	100
Canada 3/	8,790	6,830	7,570	7,880 r/	8,500 4/
Chile	254	336	424	511 r/	500
China e/	10,200	10,500	11,000	10,600	10,500
Colombia	608	639	671	439 r/	450 4/
Croatia e/	XX	XX	50	50	50
Cuba e/	130	130	125	125	125
Cyprus	37	37 e/	36 r/	90	180
Czech Republic e/	XX	XX	XX	560 r/	591 4/
Czechoslovakia e/ 5/	714 4/	624	600	XX	XX
Dominican Republic	78	118	83	85 e/	83
Egypt 3/	1,280	1,240	1,200 e/	1,200	1,200
France 3/	5,800	5,600 e/	5,160	5,000 e/	5,000
Germany (marketable): 3/					
Eastern states	2,300	XX	XX	XX	XX
Western states	2,170	XX	XX	XX	XX
Total	4,470	4,210 e/	4,350	2,680 r/	2,750
Greece e/ 3/	450 4/	450	400	400	400
Guatemala	66	52	68	60 e/	89 4/
Hungary e/ 3/	112	110	110	125 r/	125
India	1,660	1,550	1,300 r/	1,800 r/	1,900
Iran 6/	7,720	8,050	8,720	8,600	8,430 4/
Iraq e/ 7/	380	190	380	450 r/	450
Ireland	394	342 r/	343 r/	318 r/	325
Italy e/	1,260 4/	1,290	1,300	1,200	1,200
Jamaica	82	136	145	152 r/	152
Japan e/	6,400	5,400	5,400	5,500	5,300
Jordan	93	55	83	195 r/	194
Laos	53	77	80	80 e/	85
Latvia e/	XX	XX	350	300	300
Libya e/	180	180	180	180	180
Mexico 3/	5,430	4,770	5,160	5,340 r/	5,530 4/
Moldova e/	XX	XX	300	250	200
Morocco e/	450	450	450	450	450
Pakistan	478	522	462	535 r/	540
Poland 3/	916	788	843	832 r/	830
Portugal 3/	309 r/	359 r/	417	459	450
Romania e/	800	800	800	500 r/	--
Russia e/	XX	XX	1,800	1,500	1,200
Saudi Arabia e/	375	375	375	375	375
Slovakia 3/ e/	XX	XX	XX	75	70
South Africa, Republic of	391	420	334	284 r/	308 4/
Spain 3/	7,810	8,050	6,760 r/	7,250 r/	7,250
Switzerland e/	230	230	200	200	200
Syria	175	175	234	235 e/	235
Tajikistan e/	XX	XX	500	400	300
Thailand	5,750	7,200	7,110	7,450 r/	8,140
Tunisia e/	100	100	100	100	100
Turkey	172	307	278	541 r/	500
Turkmenistan e/	XX	XX	300	200	150
U.S.S.R. e/ 8/	4,500	4,000	XX	XX	XX
United Arab Emirates e/	89	95	95	95	95
United Kingdom e/ 3/	4,000	3,500	3,000	2,500 r/	2,500
United States 9/	14,900	14,000	14,800	15,800	17,200 4/
Uruguay e/	145	145	145	145	145

See footnotes at end of table.

TABLE 8--Continued

GYPSUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994 e/
Venezuela	201	244	175	224 r/	210
Yemen	66	100	80	80	80
Yugoslavia 10/	535	450 e/	XX	XX	XX
Other 11/	607	921	920	451	505
Total	104,000	100,000	100,000 r/	99,400 r/	101,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 19, 1995.

3/ Includes anhydrite.

4/ Reported figure.

5/ Dissolved Dec. 31, 1992.

6/ Data are for years beginning Mar. 21 of that stated.

7/ For cement production only. Information is insufficient to formulate reliable estimates for output for other uses (plaster, mortar, etc.).

8/ Dissolved in Dec. 1991.

9/ Excludes byproduct gypsum.

10/ Dissolved in Apr. 1992.

11/ Includes 33 countries all of which produced less than 50,000 metric tons of gypsum in 1994.

HELIUM

By Joseph B. Peterson

Grade-A helium (99.995% or better) sales volume in the United States by private industry and the U.S. Bureau of Mines (USBM) was 75.4 million cubic meters [2,719 million cubic feet (MMcf)] in 1994.[1] Grade-A helium exports by private producers were 25.0 million cubic meters (901 MMcf) for total sales of 100.4 million cubic meters (3,619 MMcf) of U.S. helium. The USBM price for Grade-A helium, f.o.b. plant, was $1.983 per cubic meter [$55 per thousand cubic feet (Mcf)], and bulk liquid helium was $2.524 per cubic meter ($70 per Mcf) on January 1, 1994, with additional costs for container services and rent. Private industry increased their helium prices last year, but they are lower than the USBM.

Legislation and Government Programs

The Federal Helium Program is designed to provide all Federal agencies with its current and estimated future helium needs to carry out other Government programs authorized and funded by Congress. The USBM major helium customers are the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), and the Department of Energy (DOE).

In accordance with the Vice President's National Performance Review (NPR), the Federal Helium Program is being re-engineered to run more efficiently. NPR suggestions to discontinue nonrevenue-producing functions and increase efficiencies of helium operations have been implemented into the operation of the Helium Program. In addition, implementation of other streamlining and revenue enhancing suggestions for Helium Field Operations is planned.

Several bills (i.e., Helium Privatization Act of 1995 and Helium Disposal Act of 1995) have been introduced in subcommittees of the 104th Congress. Most of the proposed legislation includes variations of the following points:

- Cease production and sales of Grade-A helium, leaving Federal customers to buy their helium from private industry;
- Dispose of all helium production, refining, and sales related assets;
- Sell crude from the helium reserve in an orderly manner;
- Continue operation of the helium storage system, which includes the storage fields and the pipeline system, for storage and distribution of both government-owned and privately owned crude helium;
- Continue federal land lease helium extraction contracts; and
- Cancel the helium debt.

Supporters of these activities are of the opinion that the original purpose of the Helium Act has been accomplished and that private industry is capable of supplying any anticipated helium demands from private and Federal customers.

Production

In 1994, 18 privately owned domestic helium plants were operated by 14 companies. Thirteen of the privately owned plants and the USBM plant extracted helium from natural gas. All extraction plants except one use cryogenic extraction processes. The volume of helium recovered from natural gas increased 12.7%, while sales increased about 5.1% in 1994. A shortage of private helium production was prevented by purifying crude helium that had been stored in the USBM's Cliffside Field. All natural gas processed for helium recovery came from gasfields in Colorado, Kansas, Oklahoma, Texas, Utah and Wyoming. Eight private plants and the USBM plant purified helium this year. This includes a new plant startup in Moab, UT. Pressure-swing adsorption is used for helium purification at seven of the eight private helium plants and at the USBM plant. The USBM also uses cryogenic purification for backup. The USBM and seven private plants that produce Grade-A helium also liquefy helium. The plant operators and locations are Air Products and Chemicals Inc., Hansford County, TX, and Liberal, KS; Exxon Co., U.S.A., Shute Creek, WY; BOC Gases Inc., Otis, KS; Unocal, Moab Utah; and Praxair, Inc., Bushton and Ulysses, KS. Nitrotec's helium plants near Burlington and near Cheyenne Wells, CO, produce Grade-A helium but do not liquefy it. (*See tables 1, 2, and 3, and figures 1 and 2.*)

Domestic production data for helium are developed by the USBM from records of its own operations as well as the High Purity Helium Survey, a single, voluntary canvass of private U.S. operations. Of the seven operations to which a survey request was sent, 100% responded, and those data plus data from USBM operations represent 100% of the total helium sales and recovery shown in table 2.

Domestic measured and indicated helium resources as of January 1, 1994, (the latest figures available) are estimated to be 12.7 billion cubic meters [457 billion cubic feet (Bcf)]. The resources include measured reserves and indicated resources estimated at 6.7 billion cubic meters (241 Bcf) and 0.9 billion cubic meters (32 Bcf), respectively, in natural gas with a minimum helium content of 0.3%. A slight increase in the measured reserves of helium is reported due to ongoing evaluations of the Nation's depleting helium resources. The measured reserves included nearly 1 billion cubic meters (34 Bcf) stored by the USBM in the helium conservation storage system. Measured helium resources in natural gas with a helium content of less than 0.3% are estimated to be 1.2 billion cubic meters (44 Bcf). Indicated helium resources in natural gas with a helium content of less than 0.3% are estimated to be 3.8 billion cubic meters (137 Bcf). Approximately 4.4 billion cubic meters (157 Bcf) or 91% of the domestic helium resources under Federal ownership are in the Riley Ridge area and the Church Buttes Field in Wyoming and in the Cliffside Field in Texas.

Most of the domestic helium resources are in the midcontinent and Rocky Mountain regions of the United States. The measured helium reserves are in approximately 102 gasfields in 11 States. About 86% of these reserves is contained in the Hugoton Field in Kansas, Oklahoma, and Texas; the

Keyes Field in Oklahoma; the Panhandle and Cliffside Fields in Texas; and the Riley Ridge area in Wyoming. The USBM analyzed a total of 148 natural gas samples from 16 States during 1994 in conjunction with its program to survey and identify possible new sources of helium.

Consumption and Uses

The major domestic end uses of helium were cryogenics, welding, and pressurizing and purging. Minor uses included synthetic breathing mixtures, chromatography, leak detection, lifting gas, heat transfer, and controlled atmospheres. (*See figure 3.*) The Pacific and Gulf Coast States were the principal areas of helium consumption.

The USBM sales to Federal agencies and their contractors totaled 6.61 million cubic meters (238 MMcf) in 1994, a decrease of 16.6% when compared with the prior year's sales. This decrease was due largely to slowdowns in DOD programs and budget restraints imposed on all Federal agencies by Congress.

The Federal agencies purchase their major helium requirements from the USBM. Direct helium purchases by DOD, NASA, DOE, and the National Weather Service constituted most of the USBM Grade-A helium sales. Most remaining helium sales to Federal agencies were made through USBM contract distributors, who purchased equivalent volumes of USBM helium under contracts described in the Code of Federal Regulations (30 CFR 602). Some of the contract distributors also have General Services Administration helium supply contracts. These contracts make relatively small volumes of helium readily available to Federal installations at lower freight charges by using the contractors' existing distribution systems.

Estimated 1994 domestic consumption by end use was based on a 1991 domestic end-use survey conducted to determine the trends in helium usage. The information from that survey showed that welding, pressure/purging, lifting gas, leak detection, and inert atmosphere applications were the leading usages of gaseous helium. Magnetic resonance imaging applications dominated liquid helium usage. (*See figure 3.*)

Stocks

The volume of helium stored in the USBM helium conservation storage system, including the conservation pipeline network and Cliffside Field, totaled 965 million cubic meters (34.8 Bcf) at yearend. The storage system contains crude helium purchased under contract by the USBM from 1962 to 1973 and privately owned helium stored under contract. Excess private helium is extracted from natural gas supplying fuel markets in the winter and stored by the USBM under contract. This privately owned crude helium is returned to the owners as needed for purification to supply private demand. During 1994, 38.8 million cubic meters (1,399 MMcf) of private helium was delivered to the USBM's helium conservation storage system and 20 million cubic meters (724 MMcf) was withdrawn for a net increase of 18.8 million cubic meters (675 MMcf) of private helium in storage. (*See table 4.*)

Transportation

All Grade-A gaseous helium sold by the USBM was shipped in cylinders, modules (large gas cylinders), special railway tankcars, or highway tube semitrailers. Small gas cylinders were filled at the Amarillo plant, and railway tankcars are filled at the Exell plant. The USBM discontinued sale of Grade-A gaseous helium sales via cylinder on July 1, 1994. Other shipping containers for gaseous helium can be filled at either plant. The USBM liquid helium was shipped in dewars and semitrailers from the Exell plant. Private producers and/or distributors shipped helium predominantly as a liquid in semitrailers. These semitrailers delivered the liquid helium to distribution centers where some of it was gasified and compressed into trailers and small cylinders for delivery to the end user. The remaining liquid helium was sold as bulk liquid or repackaged in dewars of various sizes for delivery.

Prices

The USBM price for Grade-A helium, f.o.b. plant, was $1.983 per cubic meter ($55 per Mcf) and bulk liquid helium was $2.524 per cubic meter ($70 per Mcf) on January 1, 1994, with additional costs for container services and rent. Private industry increased helium prices last year, but lagged behind the USBM price.

Foreign Trade

Exports of Grade-A helium, all by private industry, decreased by 10.7% in 1994 to 25 million cubic meters (901 MMcf). (*See table 3.*) Since 1992, U.S. helium exports have decreased 22.8%. About 37% of the exported helium was shipped to Europe. Belgium, France, Germany, and the United Kingdom, collectively, received about 93% of the European exports. About 40% of the U.S. helium exports went to Asia, with Japan receiving about 90%. Other exports were as follows: about 9% to North America; about 3% to Australia-New Zealand, 3.3% to the Middle East; 5.7% to South America; 1.5% to Central America; about 1% to Africa; and the remainder to the Caribbean. The shipments of large volumes of helium to Western Europe were attributed to helium uses in cryogenic research and superconducting applications. Significant volumes also were used in breathing mixtures for diving, welding, and as a lifting gas. Although no helium was imported by the United States in 1994, import tariffs on helium remained at the 3.7% rate for most favored nations established on January 1, 1987. The non-most-favored-nation tariff also remained unchanged at 25%. No changes in import tariffs are scheduled at this time.

World Review

World production of helium, excluding the United States, was estimated to be 13 billion cubic meters (469 MMcf), most of which was extracted in Poland and Russia. The remainder was produced in small plants in China and India. (*See table 5.*)

Current Research and Technology

Technology that uses liquid helium to produce superconducting temperatures continues to be developed and utilized. Liquid helium continues to be used at Fermi National Accelerator Laboratory for Tevatron/Tevatron 1, which was the world's first superconducting particle accelerator. The liquid helium-cooled superconducting magnets used in this accelerator provide an intense and extremely steady magnetic field using only a fraction of the energy required by conventional electromagnets. The Tevatron is presently the second most energetic particle accelerator in the world (1.6 trillion electron volts).

Argonne National Laboratory is developing a marine magneto hydrodynamic propulsion system for military and commercial use. This system has no moving parts, but uses magnetic fields and electricity to pump water through a tube. Researchers at Argonne used the world's largest liquid-helium-cooled superconducting dipole magnet to study this propulsion system. Development of this technology could lead to a new generation of water transportation vessels that would travel more quickly, quietly, and efficiently than present ships.

Liquid helium use in magnetic resonance imaging (MRI) continues to increase as the medical profession accepts and develops new uses for this equipment. The MRI equipment is providing accurate diagnoses of medical problems where exploratory surgery was previously required. Another medical application being developed uses MRI to determine through blood analysis if a patient has any form of cancer. Most researchers seem to think it will be at least 4 to 8 years before uses of the new high-temperature (about -184 °C or -300 °F) superconducting materials affect liquid helium demand.

Lifting gas applications are increasing. The U.S. Navy and U.S. Air Force are investigating the use of airships to provide early warning systems to detect low-flying cruise missiles. The Drug Enforcement Administration has installed six tethered radar blimps along the southern border of the United States to detect drug smugglers. In addition, NASA is now using helium-filled balloons to sample the atmosphere in Antarctica to determine what is depleting the ozone layer that protects the Earth from harmful ultraviolet radiation. In the commercial market, several companies in addition to Goodyear are now using "blimps" for advertising.

The development of Strategic Defense Initiative (SDI) weapons such as the antisatellite (ASAT) rocket, chemical laser, and rail gun has slowed with the decline of the "cold war." The ASAT rocket uses liquid helium-cooled infrared sensors for target location and guidance. Gaseous helium is used in the lasing gas mixture of the chemical laser, and liquid helium is used to cool the tracking telescope used to locate the target and aim the laser beam. High-pressure gaseous helium provides the initial push that inserts the projectile into the bore of the rail gun at a velocity of about 1,770 kilometers per hour (1,100 miles per hour). Electromagnetic energy applied along the bore accelerates the projectile to a final velocity of about 14,500 kilometers per hour (9,000 miles per hour). Superconducting magnetic energy storage (SMES) also is being investigated to provide power for DOD laser systems and electric power peak shaving in commercial applications. SMES allows the accumulation and storage of electrical energy over the long term (hours) when excess capacity is available and discharges it in minutes or as needed to provide for peak demands. Some small commercial units are already in service.

Other evolving technologies that require the unique properties of helium are (1) metastable helium for energy storage, which involves raising helium electrons to an excited energy state and then stabilizing the atom there; (2) fiber-optic production, where an ultrapure inert atmosphere is required; (3) helium-filled plastic pillows, where helium's low density is required to simulate a precursor wave from a nuclear blast; (4) helium ion tumor treatment, where large inert particles are required; (5) liquid helium-cooled superconducting microswitches, called Josephson junctions, which are much faster than conventional semiconductors and use less power; (6) "Aneutronic" nuclear fusion, where nuclear energy is produced by fusion of deuterium and helium-3, results in few or no neutrons; (7) helium-hydrogen breathing mixtures that enable deep-sea divers to reach depths below 580 meters (1,700 feet); and (8) an 11% oxygen-in-helium mixture is being used at NASA's Ames Research Center in its combustion-driven Shock Tunnel Facility. This facility is similar to a wind tunnel but provides the much higher pressures and velocities needed to test space plane models at Mach 16.

Outlook

Until recently, all superconductors required liquid helium (-269 °C or -452 °F) to reach superconducting temperatures. Current research on superconductors has resulted in the discovery of superconducting materials that operate above liquid nitrogen temperatures (-196 °C or -320 °F). These new superconductors have physical limitations, such as brittleness and poor current-carrying capacities, which have precluded their use in most superconducting applications. As these physical problems are solved, the new materials will replace liquid helium-cooled superconductors.

Since 1990, the market for U.S.-produced helium has grown at an average annual rate of 4.3%. Private industry's market has been growing at 6.2% per year, while the Federal market has dropped 41% since 1990. In 1994, private industry supplied about 91% of the domestic demand while the USBM supplied the remaining 9%. Private industry supplies all of the U.S. helium exports. The foreign market decreased in 1994, accounting for only 25% of U.S. helium sales. Helium exports have decreased 22.8% since 1992.

The outlook for helium is slowing in the Federal sector with cutbacks and elimination of programs that use large volumes of helium. High-temperature superconductors are beginning to be used in commercial applications. Continued decline in U.S. helium exports is expected due to startup of an Algerian production facility.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Helium. Ch. in Commodity Annual Report, annual.

Helium. Ch. in Minerals Commodity Summary, annual.

Information Circular 9129, Analyses of Natural Gases, 1917-85, by B. J. Moore and S. Sigler.

Information Circular 9301, Analyses of Natural Gases, 1986-90, by J. E. Hamak and S. Sigler.

Information Circular 9318, Analyses of Natural Gases, 1991, by J. E. Hamak and B. D. Gage.

Information Circular 9356, Analyses of Natural Gases, 1992, by J. E. Hamak and S. Sigler.

Information Circular 9342, Helium Resources of the United States, 1991, by J. E. Hamak and B. D. Gage.

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[1] All metric helium volumes herein reported are at 101.325 kilopascals absolute (14.696 psia) and 15 °C (59 °F). Helium volumes, reported in parentheses following metric units, are measured in cubic feet at 14.7 psia and 70 °F. One thousand cubic feet (1 Mcf) at 14.7 psia and 70 °F = 27.737 cubic meters at 101.325 kilopascals absolute and 15 °C. One cubic meter at 101.325 kilopascals and 15 °C = 36.053 ft^3 at 14.7 psia and 70 °F.

TABLE 1
OWNERSHIP AND LOCATION OF HELIUM EXTRACTION PLANTS IN THE UNITED STATES IN 1994

Category and owner or operator	Location	Product purity
Government–owned:		
U.S. Bureau of Mines	Masterson, TX	Grade–A helium1/
Private industry:		
Air Products Helium, Inc.	Hansford County, TX	Do.
Do.	Liberal, KS	Do.
Enron Helium Co.	Bushton, KS	Crude helium
Exxon Co., U.S.A.	Shute Creek WY	Grade–A helium1/
BOC Gases	Otis, KS	Do.
KN Energy, Inc.	Scott City, KS	Crude helium2/
National Helium Corp.	Liberal, KS	Crude helium
Maxus Energy Corp.	Sunray, TX	Do.
Mesa, Inc.	Fain, TX	Do.
Do.	Satanta, KS	Do.
Nitrotec	Burlington, CO	Grade–A helium
Do.	Cheyenne Wells, CO	Do.
Trident NGL, Inc.	Ulysses, KS	Crude helium
Phillips Petroleum Co.	Dumas, TX	Do.
Do.	Hansford County, TX	Do.
Praxair, Inc.	Bushton, KS	Grade–A helium1/
Do.	Elkhart, KS	Deactivated
Do.	Ulysses, KS	Grade–A helium1/
Unocal	Moab, UT	Grade–A helium1/

1/Including liquefaction.
2/Output is piped to Ulysses, KS, for purification.

TABLE 2
HELIUM RECOVERY IN THE UNITED STATES1/
(Thousand cubic meters)

	1990	1991	1992	1993	1994
Crude helium:					
U.S. Bureau of Mines total storage	(12,800)	(9,550)	(9,360)	(8,850)	(7,200)
Private industry:					
Stored by U.S. Bureau of Mines	14,100	26,600	25,300	29,600	38,800
Withdrawn	(21,300)	(18,100)	(17,900)	(16,400)	(19,500)
Total private industry storage	(7,200)	8,500	7,400	13,200	19,300
Total crude helium	(20,000)	(1,050)	(1,960)	4,350	12,100
Stored private crude helium withdrawn from storage and purified by the U.S. Bureau of Mines for redelivery to industry	(178)	(613)	(510)	(638)	(610)
Grade–A helium:					
U.S. Bureau of Mines sold	11,200	9,400	8,630	7,930	6,610
Private industry sold	73,700	78,700	85,800	87,600	93,800
Total sold*	84,900	88,100	94,400	95,500	100,000
Total stored	20,200	(1,660)	(2,470)	3,710	11,500
Grand total recovery	105,000	86,400	91,900	99,200	112,000

1/Negative numbers are enclosed in parenthesis ( ) to denote net withdrawal from the USBM's unc storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.
*Sums may appear incorrect due to rounding.

TABLE 3
TOTAL SALES OF GRADE-A HELIUM PRODUCED IN THE UNITED STATES
(Million cubic meters)

	Volume		
Year	Domestic sales	Exports1/	Total sales
1990	60.1	24.7	84.8
1991	61.0	27.1	88.1
1992	63.7	30.7	94.4
1993	67.6	28.0	95.6
1994	75.4	25.0	100.4

1/Source: Bureau of the Census.

TABLE 4
SUMMARY OF U.S. BUREAU OF MINES HELIUM CONSERVATION STORAGE SYSTEM OPERATIONS 1/ 2/

(Thousand cubic meters)

	1992	1993	1994
Helium in conservation storage system at beginning of period:			
Stored under U.S. Bureau of Mines conservation program	903,000	894,000	885,000
Stored for private producers under contract	49,200	56,100	68,700
Total	952,000	950,000	954,000
Input to system:			
Net deliveries from U.S. Bureau of Mines plants 3/	(9,360)	(8,850)	(7,200)
Stored for private producers under contract	25,300	29,600	38,800
Total	15,900	20,800	31,600
Redelivery of helium stored for private producers under contract 3/	(18,400)	(17,000)	(20,000)
Net addition to system 3/	(2,420)	3,780	11,500
Helium in conservation storage system at end of period:			
Stored under U.S. Bureau of Mines conservation program	894,000	885,000	878,000
Stored for private producers under contract	56,100	68,700	87,500
Total	950,000	954,000	966,000

1/ Crude helium is injected into or withdrawn from the USBM's underground storage facility, a partially depleted natural gas reser Cliffside Field near Amarillo, TX.

2/ Previously published and 1994 data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown

3/ Numbers in parentheses indicate net withdrawl from storage.

TABLE 5
WORLD GRADE-A HELIUM PRODUCTION CAPACITY, DECEMBER 31, 1994
(Million cubic meters)

	Capacity
United States/1	114
Rest of world/e	13
Total/e	127

e/Estimated.

1/Includes capacity of plants on standby as well as operating plants.

Figure 1
HELIUM RECOVERY IN THE UNITED STATES

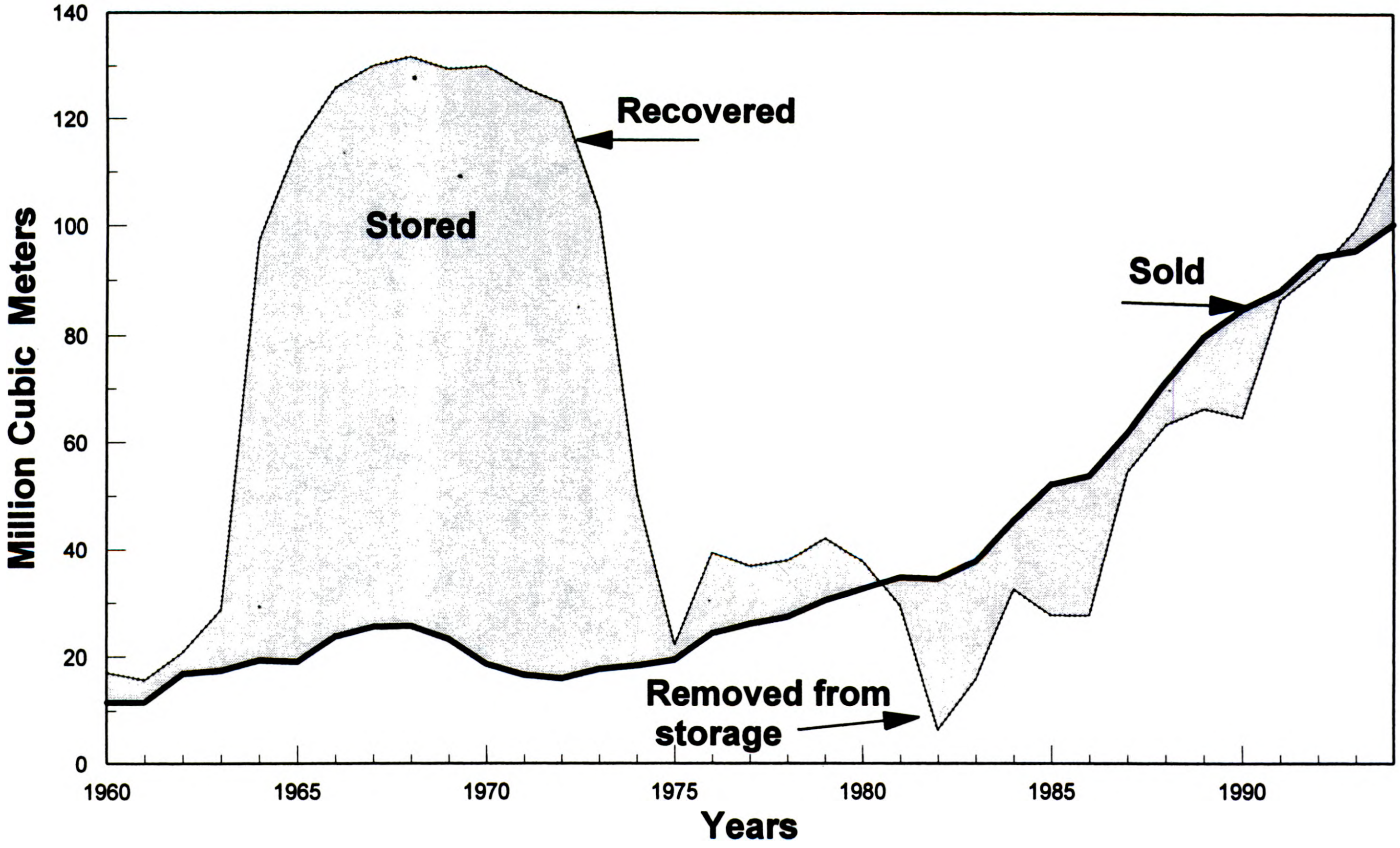


FIGURE 2
MAJOR U.S. HELIUM-BEARING NATURAL GAS FIELDS

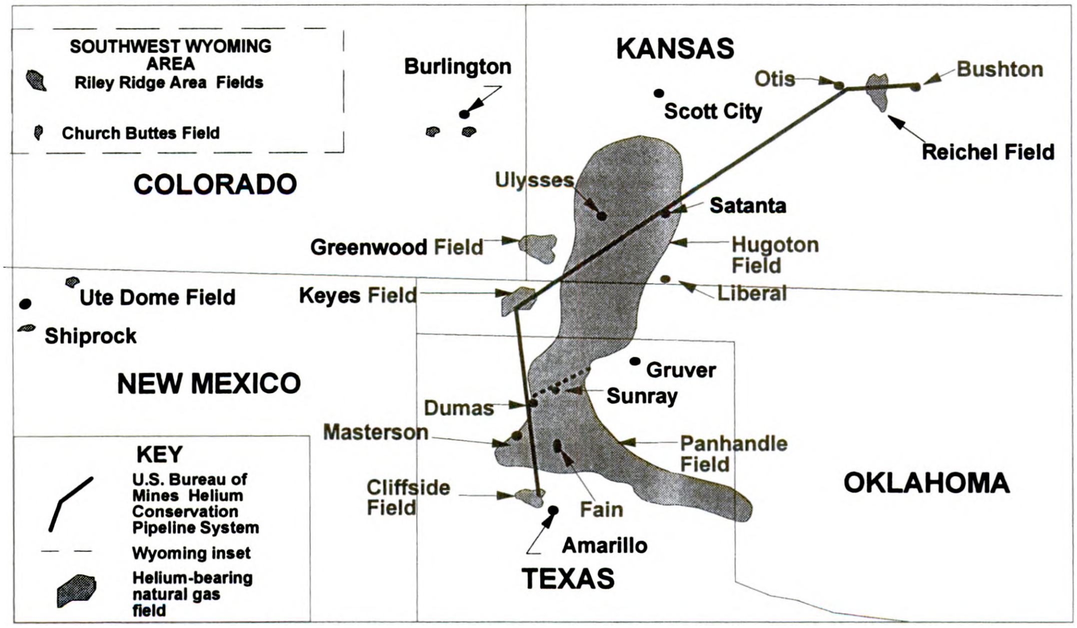
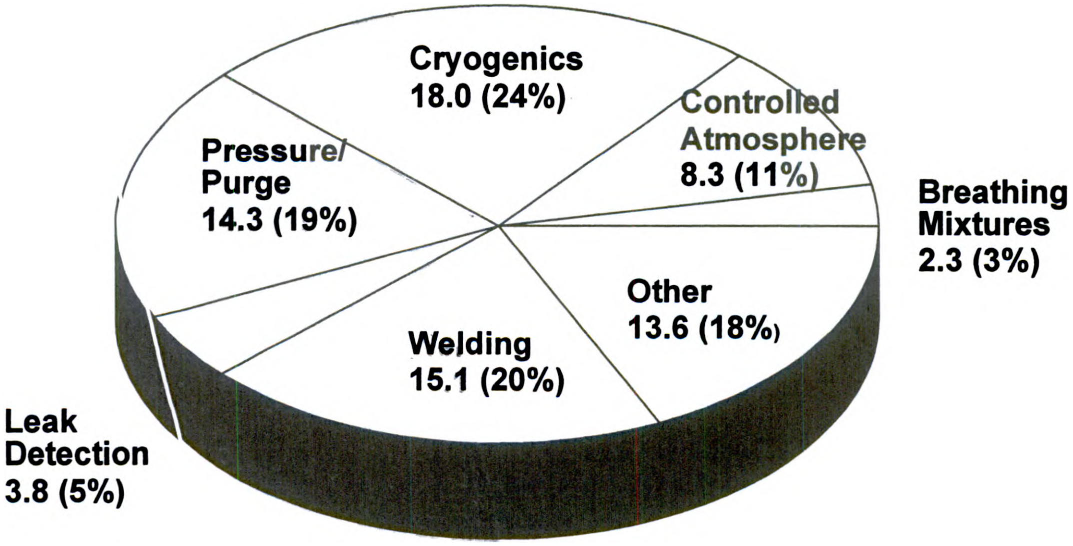


FIGURE 3

ESTIMATED HELIUM CONSUMPTION, BY END USE, IN THE UNITED STATES IN 1994

(Million cubic meters)



Estimated total helium used
(75.4 million cubic meters)

INDIUM

By Robert D. Brown Jr.

Domestic indium production was confined almost entirely to the upgrading of imported metal. There was no known production at domestic mines. Two companies, one each in New York and Rhode Island, were the major producers of indium and indium products. Several smaller firms also produced high purity indium alloys, compounds, solders, sputtering targets, and related products.

Domestic consumption increased from 35 to 40 metric tons. The estimated use pattern was as follows: coatings, 45%; solder and alloys, 35%; electronic and semiconductor uses (including batteries), 15%; and research and other uses, 5%. The estimated value of primary metal consumed in 1994 was $5.4 million.

World refinery production was estimated at 145 tons, a slight increase over that of 1993. Eleven countries produced indium; the top five producers accounted for 83% of the total. World consumption increased, nearly equaling production. This caused world prices to remain steady most of the year. In 1993, the average domestic producer price had dropped from $200 per kilogram in January to $175 at yearend; it fell to $150 per kilogram in the first quarter of 1994 and fluctuated very little throughout the remainder of the year.

Legislation and Government Programs

The Defense National Stockpile Center inventory of indium on December 31 was 1,561 kilograms, the same as it was a year before. The stockpile goal for indium was 7,740 kilograms.

Late in 1992, telemarketing firms began selling indium to investors at highly inflated prices. These activities were investigated by law enforcement agencies in the United States and Canada. The Federal Trade Commission prepared a consumer information brochure on Investing in Indium and other "Strategic Metals."1 Most of these firms were based in Canada, but as investigations increased, several of them moved to the Caribbean. As the real price showed signs of increasing at the end of 1994, several investors began to try to sell. Some found for the first time that they had bought at inflated prices.

Production

U.S. production consisted of upgrading standard grade indium (99.97% or 99.99%) into higher purity metal. There was no known production at domestic mines; all the standard grade indium was imported. Indium can be refined to purities up to 99.99999% in the United States. Domestic secondary production was mainly from new scrap and spent sputtering targets. The amount of indium produced from scrap was small compared to that produced from imported metal.

Consumption

Domestic consumption was estimated at 40 metric tons, a 14% increase from 1993. Indium was available in various forms, such as ingot, foil, powder, ribbon, shot, and wire.

Thin film coatings on glass, which included indium oxide and indium-tin-oxide (ITO), constituted 45% of total domestic indium use in 1994. The coatings, produced by sputtering the material onto the glass, have been the largest area of growth and research for indium in the past several years.

There are two kinds of indium-containing coatings, electrically conductive and infrared reflecting. Electrically conductive coatings, the largest group, are used primarily in liquid crystal displays (LCD's) for watches, television screens, portable computer screens, video monitors, etc. They are also used to defog aircraft and locomotive windshields and to keep glass doors on commercial refrigerators and freezers frost free. Infrared reflecting coatings on window glass are used to control energy losses by reflecting heat inward in winter and outward in summer. About 35% of the indium was used as an addition to bismuth, cadmium, lead, or tin alloys to lower their melting points. These alloys are used in such applications as electrical fuses, fusible links, or as holding material for the grinding of optical glass. Indium is used as a strengthening agent for lead solder and as the base material for many low-melting-point solders. Indium-based solders have the advantages of lower melting points, flexibility over a greater temperature range, no leaching from gold components, and the possibility of being made lead-free. A new solder, Indalloy 227, containing 20% indium, 2.8% silver, and the balance tin, was introduced in 1994. This alloy was designed to be a direct competitor to conventional 63% tin-37% lead solder.2

The use of indium in batteries has grown in the last 2 years; it replaces mercury in alkaline batteries, preventing the build up of hydrogen gas in the sealed container. The batteries were available in popular small consumer sizes, and together with other electronic uses, accounted for 15% of the indium consumed domestically.

Prices

The domestic producer price for 99.97%-99.99% pure indium remained nearly steady throughout the year. Having been lowered from $200 to $175 per kilogram during 1993, it was lowered to $150 per kilogram during 1994 and was increased to $170 per kilogram in the first week of 1995. By midyear, 1994, it had become apparent that Japanese imports were increasing dramatically, but a fairly steady flow of indium from Russia kept prices from being increased.3 Prices for higher grades of metal were not available.

Foreign Trade

After reaching a record high of 73,400 kilograms during 1993, domestic imports fell 4% to 70,200 kilograms during 1994. Canada had the largest increase in exports to the United States and remained the largest supplier. Russia became the second ranked supplier. Export data were unavailable.

World Review

Italy. The Indium Corporation of America opened a sales office in Turin, Italy, to serve both European and Japanese Markets in 1994. The company's other office in Europe is in Bedford, United Kingdom.[4], Japan. Japan remained the world's largest consumer of indium. Its consumption was estimated at more than 80 metric tons in 1994, compared with nearly 70 tons in 1993. In 1994, about 45 tons was used for ITO.[5]

The Sharp Corporation, Takicho, Japan, began operations at what it says is the world's largest factory for thin film transistor LCD's in January 1994. In the making of these transistors, layers of ITO are coated onto the glass plates of LCD screens. The NEC Corporation is also rapidly increasing its LCD output. In spite of this activity, prices remained steady. This was partly because the yields for ITO coatings can be quite low (20% to 30%), but the scrap can be directly recovered. Additionally, as a new plant progresses on its learning curve, there is less scrap as yield increases.[6]

Russia. Although Western indium producers felt that uneven quantity and quality of Russian exports would continue to account for a premium for Western indium, the presence of Russian metal in the market was the main factor leading to steady or decreasing prices.[7]

Current Research and Technology

Researchers at Northwestern University, Evanston, IL, discovered that replacing some of the aluminum in AlGaAs diode lasers with high purity indium would increase the lifetimes of these devices. At the Indium Corporation of America, Utica, NY, ultrafine indium powders were being developed. The smaller particle size allows an increase in the density (to nearly 95% of single crystal density) of sputtering targets for depositing layers of ITO on flat panel displays. The higher density prevents premature target failure.[8]

Outlook

World reserves and increases in production capacity are sufficient to meet expected demand for indium through the next decade. Consumption of indium is expected to increase during this period, especially for liquid crystal displays, high definition TV, semiconductor materials, batteries, and low temperature solders for military and electronic applications. Other uses, such as replacement nuclear control rods and fusible alloys, should remain steady. Apparent surges in demand or breaks in supply may cause increases in price. If indium prices go too high, research into substitutes for ITO for LCDs will be stimulated. Zinc-tin-oxide could possibly be used as a substitute, but currently its properties are not as good as those of ITO.

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[1] Federal Trade Commission
Bureau of Consumer Protection
Office of Consumer & Business Education
Washington, DC 20580
Telephone: 202-326-3650.
To register a complaint, the FTC recommends calling the National Fraud Information Center at 1-800-876-7060 or a local office of the Federal Bureau of Investigation.

[2] Metal Bulletin, Bright Prospects Seen for Lead-free Solder. No. 7913, 15 September, 1994, p. 9.

[3] ———. Producers Try to Meet Indium Demand. No. 7888, June 16, 1994, p. 9.

[4] ———. Japanese Imports of Indium Rise. No. 7962, March 13, 1995, p.11.

[5] Fineburg, S., Indium Opens Sales Office in Italy. Am. Met. Mark., v. 102, No. 190, Oct. 3, 1994, p. 6.

[6] Metal Bulletin Indium Outlook Bright Despite Low Prices., No. 7857, Feb. 21, 1994, p. 9.

[7] ———. Indium Producers Dismiss CIS Threat. No. 7834, Nov. 25, 1993, p. 9.

[8] R&D Magazine, Reducing Impurities Pays Off Big in High-Tech Applications. V. 36, No. 12, Nov. 12, 1994, p. 31.

TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF INDIUM, BY CLASS AND COUNTRY 1/

Class and country	1993		1994	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Unwrought and waste and scrap:				
Belgium	4,850	$735	2,880	$338
Brazil	90	20	--	--
Canada	25,900	4,940	39,500	5,030
China	399	47	--	--
Estonia	--	--	91	10
Finland	3,100	313	78	8
France	11,500	1,690	5,130	750
Germany	68	7	160	16
Italy	17,200	2,180	3,750	392
Japan	1,490	360	1,930	643
Peru	--	--	2,660	279
Russia	3,790	425	11,600	1,220
United Kingdom	5,000	740	2,470	258
Total	73,400	11,500	70,200	8,950

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

IODINE

By Phyllis A. Lyday

Three producers of crude iodine supplied approximately 55% of domestic demand; the remainder was imported. Because some exports and imports are in product categories rather than crude products, net imports are not clearly developed. The major world producer, Japan, produced iodine from brines associated with gas production. The second largest producer, Chile, produced iodine as a coproduct of sodium nitrate.

Legislation and Government Programs

On January 12, 1994, The Environmental Protection Agency (EPA) published in the Federal Register, Vol. 59, No. 8, a temporary tolerance for the combined residues of the fungicide Iprodione, its isomer and its metabolite in or on the raw agricultural commodity cotton seed. The temporary tolerance expires January 1, 1996.

EPA halted reviews of 60 pesticide registrations that may violate the zero-risk Delaney clause and plans to revoke 25 of 80 existing pesticide registrations on the same basis. The Delaney clause bans cancer-causing chemicals from processed foods.[1]

The EPA planned to add 313 chemicals and chemical categories to the list of toxic chemicals required to be reported under the Toxic Release Inventory (TRI). The proposal published in the January 12 Federal Register, Vol. 59, No. 8. p. 1794 included two iodine compounds. The Defense National Stockpile contained 2,501,732 kilograms (kg) of crude iodine. The stockpile goal for iodine was reduced to zero with the passage of Public Law 102-484 on October 23, 1992.

On September 28, 1994, The Defense National Stockpile Center awarded 116,120 kg (256,000 pounds) of crude iodine to West Agro, Inc., and Chemland, Inc. The total value of the awards was $1,009,397.49 or $8.69 per kg.

In December, 102,386 kg (225,723 pounds) of crude iodine was awarded to West Agro and IOCHEM Corp. The total value of the awards was $941,594.91, or $9.20 per kg.

Production

Domestic production data for iodine are developed by the U.S. Bureau of Mines from a voluntary survey of U.S. operations. Of the three operations to which a survey request was sent, two responded, representing an estimated 51% of the total production shown in tables 1 and 6. *(See tables 1 and 6.)*

IOCHEM began production in 1987, 1.2 kilometers east of Vici, Dewey County, OK, by the blowing-out process. The majority of production was shipped to Schering AG, Germany, under a long-term contract. IOCHEM was reported to have nine production wells and four injection wells with a total production capacity of 1,400 kg per year.

North American Chemical Co. began operating a miniplant at Dover in Kingfisher County, OK, in 1983. Two plants are at an oilfield injection disposal site that obtains brines from about 50 wells in the Oswego Formation. Iodine concentrations ranged up to 1,200 parts per million. The company closed a plant in 1992 that began operating in 1991 because of the low-market prices for iodine.

Woodward Iodine began production in 1977 and was purchased by Asahi Glass Co. of Japan in 1984. Woodward operated a plant in Woodward County that produced iodine from 22 brine production wells using the blowing-out process and injected waste through 10 injection wells.

Consumption

Iodine deficiency is the world's leading cause of mental defects in the form of severe retardation, deaf-mutism, and partial paralysis and more subtle problems such as clumsiness, lethargy, and reduced learning capacity. Iodine is an essential part of thyroid hormone, a substance that contributes to brain development during fetal life and metabolism thereafter. A worldwide effort is underway to eliminate iodine-deficiency disorders by fortifying the world's salt supply. The international salt iodization campaign will pay for simple machinery that adds iodate to crystallized salt, and for the quality control and education necessary to ensure the transformation is permanent.[2]

Tall oil rosin (TOR) is used as a "paper size," and in ink resins and tackifying resins for adhesives. The main competition for TOR is hydrocarbons resins made from byproducts of ethylene production.[3] Three U.S. companies use iodine to stabilize TOR.

Deepwater Iodide Inc., agreed in April 1994 to sell 80% of the company to LSB Chemical Corp., a division of Oklahoma City based LSB Industries Inc. LSB Chemical has businesses in nitric acid and ammonium nitrate and in air conditioning products. Deepwater has $12 million in annual sales and production of a fire extinguishing replacement for Halon 1301 that used iodine and fluorine. The new plant that was to go on-stream in mid-1994 in Woodward, OK, will triple the iodine capacity of the previous plant located in California.

Iodotrifluoromethane (CF_3I) can replace Halon 1301 for total flooding and streaming applications as a fire extinguishing agent. Test conducted by the U.S. Air Force have shown that CF_3I performs at least as well as Halon 1211. The ozone depletion potential (ODP) of CF_3I is zero. CF_3I has been found to be "nontoxic." Flow test shows that CF_3I works well in existing Halon 1301 distribution systems with little or no hardware modifications.[4]

Iodine was used primarily in animal feed supplements, catalysts, inks and colorants, pharmaceutical, photographic equipment, sanitary and industrial disinfectants, stabilizers, and radiopaque medium. Other smaller uses included production of batteries, high-purity metals, motor fuels, iodized salt, and lubricants. *(See table 2.)*

Prices

Tall oil rosin (TOR) prices increased in August, which responded to a rosin resin increase effective January 1, 1995. Pricing for all TOR derivatives will increase 5% to

12%.[5]

The averaged declared c.i.f. value for imported crude iodine was $7.56 per kg. The average declared c.i.f. value for imported crude iodine from Japan was $7.41 per kg. The average declared c.i.f. value for iodine imported from Chile was $7.82 per kg. The average producer price was $7.98 per kg. Quoted yearend U.S. prices for iodine and its primary compounds are shown in table 3. *(See table 3.)*

Foreign Trade

The U.S. Government adopted the Harmonized Commodity Description and Coding System (Harmonized System) as the basis for its export and import tariff and statistical classification systems. The system is intended for multinational use as a basis for classifying commodities in international trade for tariff, statistical, and transportation purposes. The Harmonized System, as proposed, includes resublimed and crude iodine under the same code, and the duty rate is free. Values that differ significantly could be a result of items being placed in the wrong category. *(See tables 4 and 5.)*

World Review

Chile.—Sociedad Quimica y Minera de Chile (SQM, formerly known as SOQUIMICH) closed two satellite plants late in 1994 to maintain stability in the marketplace. A 100,000-ton-per-year potassium nitrate plant opened at Coya Sur, in northern Chile. Iodine is produced as a byproduct of nitrate production. SQM had invested $1.5 to $2.0 million in a project that boosted productivity by 65% and cut production costs by 30% in the last 5 years. All facilities were International Standards Organization (ISO) certified. SQM holds a patent on prilled iodine, which is preferred by some consumers because of its ease in pouring and lack of dust. SQM is producing iodine derivatives through a subsidiary Inquim, and marketing the derivites to South America and Asia.[6] SQM announced the construction of a new plant in the Salar de Lagunas to produce sodium nitrate.[7]

Compania Salitre Y Yodo de Chile, COSAYACH, part of a multisectorial Inverraz S.A., mines raw material in the form of boron, chlorides, iodine, magnesium from caliche, nitrates, and sulfates. COSAYACH has assets of 190,000 acres of mining claims located in the Atacama and Antofagasta deserts. Reserves are estimated as 356,000 tons of iodine, 46,000,000 tons of sodium nitrate, and 80,000,000 tons of sodium sulfate. Present capacity exceeds 340 tons of iodine per year. Planned capacity increases in Cala-Cala and construction of an additional plant at Chinquiquiray are planned to reach a production level of 1,000 tons per year by 1997.[8]

Haifa Chemicals, Israel, and DSM N.V., Netherlands, have agreed to build a sodium and potassium nitrate plant in the Salare de Lagunas of northern Chile. Haifa agreed to purchase 15% of DSM's shares in the company. DMS has a 75% share in ACF Minera Ltda. The plant would use the waste nitrates from ACF Minera's iodine production to produce 40,000 tons per year of nitrates. Haifa will market all the nitrates produced.[9]

KAP Resources Ltd., Vancouver, Canada, has secured financing for a potassium nitrate project in northern Chile. The nitrates are reported to also contain high concentration of iodides. New investors are members of Canpotex, the Canadian potash export firm. The Canadian interest received a 19% in KAP in exchange for a $5 million investment. KAP plans to raise $41 million for the project that will produce 250,000 tons per year of potassium nitrate and iodine as a coproduct.[10]

The Sierra de Tarapaca's iodine plant and ore reserves were auctioned in March 1994.[11]

Japan.—Japan was the world's leading producer of iodine in 1994. Six companies operated 17 plants with a total production capacity of 9 million kg per year. Two small plants closed in midyear 1994. Production of iodine was from underground brines associated with natural gas.

Russia.—Tyumen Oblast administration and the West Siberian regional geological center are inviting bids for the right to complete surveying and to extract iodine at the Cherkashinskoye deposit. Project development will require $3.8 million. Commercial iodine extraction is from two deposits in Russia in Krasnodar Kray and perm Oblast.[12] *(See table 6.)*

Current Research and Technology

Every photograph is created by light rays that make marks on photosensitive material such as silver salts, usually silver iodide. Silver's chemical properties make it the best photomaterial for everything from beach scenes to X-rays. Photograph companies are trying to revolutionize everyday photography by producing a "smart film." Five of the world's largest film and camera companies formed a partnership to develop a new technology to revolutionize 35 mm photography. The film is "smart" because it has magnetic strips, which can record data that will later be read and translated onto prints by compatible photo-finishing equipment. Additionally, the film can be shot in three different formats, perhaps even on the same roll. The new film may be polyester-based instead of the traditional cellulose triacetate, translating into a stronger film than can be stretched thinner. A polyester-based film would not require methylene chloride needed for acetate based films. Methylene chloride has been labeled as a carcinogen by the EPA.[13]

Iodine may be part of a new scenario as a facilitator in ozone depletion. Some scientists believe, based on a number of assumptions, that iodine reaches the stratosphere and is a facilitator to make chlorine and bromine more potent. The huge volume of natural iodocarbons produced by marine life dwarfs potential industrial emissions. Iodocarbons usually break down when exposed to sunlight. Concern is for methyl iodide in thunderclouds that form in the tropics where idocarbons could reach the ozone layer in just a few hours.[14]

A group of researchers at the University of Utah, Salt Lake City, has synthesized a family of molecular squares. A postdoctoral fellow produced hybrid squares with iodides occupying opposite corners and platinum or palladium at the other corners. The compounds are soluble in organic solvents. The self-assembling molecular squares could eventually prove useful as a hosts for anions.[15]

Chemists at Emory University in Atlanta created a "smart" molecular catalyst that both self-assembles and catalyzes a reaction using idosylbenzene.[16]

Mercury iodide crystals intended for use as X-ray detectors must be coated for protection against moisture and other contaminants. The coatings are thermoplastic polymers derived from paraxylene that are used to make pore-free coatings and thin dielectric films in capacitors. To improve the quality of the polymeric deposit, the pyrolysis temperature was increased and barriers or baffles were added to the pyrolysis tube. The resulting coating was of better quality, including greater transparency and more uniformity of appearance.[17]

Outlook

Iodine production capacity in the United States and Chile has doubled during the past decade, ensuring an adequate world supply. Uses for iodine in specialty chemicals have remained stable. Recent developments in digital images using computers can produce electronic prints and overhead transparencies without using processing. Using a digital camera or scanning the film and converting to digital, the images are produced and stored on hard drives, disks, tape, or optical storage.

The trend to digital imaging is used for recording most sporting events, game shows, and some situation comedies for broadcasts. However, 75% to 85% of all televised shows seen during prime time are recorded on 35-millimeter (mm) motion picture film and then transferred to video tape or laser disc for display. Furthermore, just about all feature films for movie theater presentation are shot and printed on film. The main reason is the image quality. A frame of 35-mm color negative film contains about 6.6 million pixels or about 15 times that of the best current high-definition television system and 4 times that of the digital systems now in development. Most popular home video rentals have been box office movie hits. Future use of iodine in films and processing could be limited to specialty imaging in the next decade.[18]

New uses of fluoroiodocarbon as halogen replacements may cause an increased demand for iodine. More tests need to be completed on the IFC's before they are acceptable, but preliminary tests are promising.

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TABLE 1
SALIENT IODINE STATISTICS 1/

(Thousand kilograms and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Production	1,973	1,999	1,995	1,935	1,628
Imports for consumption 2/	3,168	3,555	3,745	3,615	4,392
Exports 2/	2,100	1,317	1,807	1,219	1,254
Consumption: 3/					
Apparent	3,041	4,327	3,933	4,331	4,766
Reported	3,100	3,200	3,400	3,547	3,599
Price, average c.i.f. value, dollars per kilogram	$13.78	$10.16	$9.03	$7.98	$8.02
World: Production	17,113 r/	17,448 r/	16,581 r/	16,625 r/	14,800 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Bureau of the Census.

3/ Calculated by production plus imports minus exports.

TABLE 2
U.S. CONSUMPTION OF CRUDE IODINE, BY PRODUCT 1/

Product	1993		1994	
	Number of plants	Consumption (thousand kilograms)	Number of plants	Consumption (thousand kilograms)
Reported consumption:				
Resublimed iodine	8	170	9	205
Hydriodic acid	3	289	3	30
Calcium iodate	(2/)	(2/)	2	94
Calcium iodide	3	121	--	--
Cuprous iodide	3	81	3	79
Potassium iodide	5	650	8	668
Potassium iodate	3	49	3	40
Sodium iodide	4	62	6	93
Other inorganic compounds	9	525	10	664
Ethylenediamine dihydroiodide	3	654	3	671
Povidone iodine	3	361	--	--
Other organic compounds	7	585	7	1,060
Total	27 3/	3,550	25 3/	3,600
Apparent consumption	XX	4,330 r/	XX	4,770

r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Included with calcium iodide.

3/ Nonadditive total because some plants produce more than one product.

TABLE 3
YEAREND 1994 PUBLISHED PRICES OF ELEMENTAL IODINE AND SELECTED COMPOUNDS

	Dollars per kilogram 1/	Dollars per pound 1/
Calcium iodate, FCC drums, f.o.b. works	16.42	7.45
Calcium iodide, 50-kilogram drums, f.o.b. works	30.00	13.61
Iodine, crude, drums	9.00-10.00	4.08-4.54
Potassium iodide, U.S.P., drums, 5,000-pound lots, delivered	26.48	12.01
Iodine, U.S.P.	37.48	17.00
Sodium iodide, U.S.P., crystals, 5,000-pound lots, drums, freight equalized	36.38	16.50

1/ Conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiations and/or somewhat different price quotations.

Source: Chemical Marketing Reporter. V. 247, No. 1, Jan. 2, 1995, pp. 27-32.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF CRUDE IODINE, BY TYPE AND COUNTRY 1/

(Thousand kilograms and thousand dollars)

Country	1993 Quantity	1993 Value 2/	1994 Quantity	1994 Value 2/
Iodine, crude:				
Canada	--	--	3	52
Chile	1,620	13,000	1,560	12,200
Germany	--	--	7	262
Russia	--	--	18	130
Japan	1,880	14,700	2,670	19,800
Total	3,500	27,700	4,260	32,400
Iodide, potassium:				
Brazil	--	--	3	11
Canada	17	184	45	437
Chile	14	123	13	133
India	49	452	14	123
Italy	--	--	7	29
Japan	34	238	52	422
Total	114	997	134	1,160
Grand total	3,620	28,700	4,390	33,600

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Declared c.i.f. valuation.

Source: Bureau of the Census, as adjusted by the U.S. Bureau of Mines.

TABLE 5
U.S. EXPORTS OF CRUDE IODINE, BY TYPE AND COUNTRY 1/

(Thousand kilograms and thousand dollars)

Country	1993		1994	
	Quantity	Value 2/	Quantity	Value 2/
Iodine, crude/resublimed:				
Brazil	--	--	19	153
Canada	28	312	80	736
Costa Rica	--	--	1	86
Egypt	--	--	2	25
Germany	573	5,078	518	3,766
Ghana	--	--	3	58
India	--	--	17	123
Italy	--	--	1	14
Jamaica	--	--	8	18
Mexico	380	2,865	491	3,920
Netherlands	--	--	2	45
Philippines	16	33	--	--
Saudi Arabia	--	--	9	6
Turkey	--	--	1	22
United Kingdom	--	--	11	69
Other 3/	19	269	1	26
Total	1,016	8,557	1,164	9,067
Iodide, potassium:				
Australia	--	--	3	55
Belgium	--	--	19	185
Canada	23	360	29	450
China	148	479	--	--
Germany	5	50	--	--
Mexico	--	--	3	61
Panama	--	--	2	6
Thailand	--	--	19	45
Turkey	14	186	15	173
Other 4/	13	103	(5/)	15
Total	203	1,178	90	990
Grand total	1,219	9,735	1,254	10,057

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Declared f.a.s. valuation.

3/ Includes Australia, The Bahamas (1993), Colombia, Ghana (1993), Italy (1993), Peru (1993), and Sweden.

4/ Includes Chile (1993), Colombia, Hong Kong, The Republic of Korea (1993), Peru, Saudi Arabia (1993), and Spain.

5/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 6
CRUDE IODINE, WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand kilograms)

Country	1990	1991	1992	1993	1994 e/
Azerbaijan e/	XX	XX	600	500 r/	400
Chile	3,980 r/	5,450 r/	5,840 r/	5,550 e/	5,600
China e/	500	500	500	500	500
Indonesia	60	36	35 e/	14 r/	15
Japan	7,580	7,490	6,760	6,490 r/	6,400
Russia e/	XX	XX	200	180 r/	160
Turkmenistan e/	XX	XX	600	500 r/	251
U.S.S.R. e/ 3/	1,900	1,800	XX	XX	XX
United States	1,970	2,000	2,000	1,940	1,430
Total	16,000 r/	17,300 r/	16,500 r/	15,700 r/	14,800

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 9, 1995.

3/ Dissolved in Dec. 1991.

IRON AND STEEL

By Gerald W. Houck

Iron and steel are vital to the United States for both national security and economic well-being. They are the basic metals of an industrial society. Although there are many acceptable substitutes for many of their uses, in the short term, there are no practical substitutes on a large scale because of the cost and lack of availability of alternative materials.

Data tables on ferroalloys production and consumption are contained in this chapter. Ferroalloys are alloys of iron that contain a sufficient amount of one or more other chemical elements to be useful as an agent to introduce these other elements into a molten metal, usually steel. The reader is referred to the Annual Reports dealing with specific elements, especially those for chromium, manganese, and silicon, for analysis and detail with respect to the ferroalloys industry.

Consistent with international usage, the U.S. Bureau of Mines is reporting all data on iron and steel in metric units, unless otherwise noted.

This was a turnaround year for the U.S. steel industry. Demand for steel products was strong and resulted in markedly improved prices. Largely as a result of the improved pricing, all major U.S. steel companies reported operating profits for the year. Production of raw steel in the United States increased 2.7%, to 91.2 million metric tons, from 88.8 million tons produced in 1993. Net shipments of steel mill products by U.S. companies increased 6.8% to 86.3 million tons, from 80.8 million tons in 1993. Shipments of U.S. steel companies were inflated by a major increase in imports of semifinished steel with which they supplemented raw steel production capability.

Imports of steel mill products increased about 54%, to 27.3 million tons, from 17.7 million tons in 1993. Imports captured 26% of the apparent consumption of steel mill products, up from 19% in 1993. Imports of fabricated steel products, such as fasteners, wire, and fabricated structural steel, totaled 2.4 million tons, representing another 2% of the U.S. steel market.

Exports of steel mill products declined to 3.5 million tons, from 3.6 million tons in 1993.

Prices of steel mill products in the United States increased in 1994. The Bureau of Labor Statistics' Producer Price Index for steel mill products increased about 4.8% to 113.4 (1982 base=100.0).

World production of raw steel in 1994 was 726 million tons, down slightly from that of 1993. Production continued to decline in the states that comprise the former U.S.S.R., dropping about 20 million tons in 1994, but elsewhere in the world, steel production increased about 5%, offsetting the decline.

Production

Production of raw steel in the United States increased 2.7% to 91.2 million metric tons, from 88.8 million tons produced in 1993. Raw steel production capability was estimated by American Iron and Steel Institute (AISI) as 98.1 million tons, down from 99.7 million tons in 1993. Production in 1994 represented 93.0% of estimated capability, compared with 89.1% in 1993.

Net shipments of steel mill products by U.S. companies increased about 7%, to 86.3 million tons, from 80.8 million tons in 1993.

"Steel mill products" refers to products produced by a steel mill, either by forging or rolling, in the form normally delivered for fabrication or use. Some companies purchase semifinished steel mill products from other steel companies and use these semifinished products to produce steel mill products. To avoid double counting steel mill product shipments under these circumstances, steel mills identify any shipments of steel mill products to other companies that are reporters of steel mill product shipments. The accumulated shipments of all companies, less the shipments to other reporting companies, are identified as "net" shipments.

Basic oxygen steelmaking was utilized for 55.4 million tons, 60.7% of raw steel production in 1994. Basic oxygen furnaces are used by integrated steel producers that smelt iron ores to crude liquid iron in blast furnaces and refine the iron, with some scrap, in basic oxygen furnaces, producing liquid steel. The liquid steel is mostly cast into semifinished products in continuous casting machines, although 10% of U.S. production in 1994 was cast in ingot form and subsequently rolled into semifinished form. The integrated steel industry in the United States in 1994 consisted of 15 companies operating ironmaking and steelmaking facilities at 22 locations. Several of these companies also operated nonintegrated plants and/or other steelmaking facilities at the same locations.

Electric arc furnace steelmaking was utilized for 35.9 million tons, 39.3% of total steelmaking in 1994. Electric arc furnaces are used by nonintegrated steel producers to melt raw materials, primarily scrap. Broadly speaking, there are two subcategories of nonintegrated mills: minimills and specialty mills. "Minimills" is a term used to describe steel producers that utilize modern technology in a plant built to produce a limited product line with maximum efficiency. These plants always incorporate electric melting of low-cost raw materials, continuous casting, and a hot-rolling mill, often closely coupled to the casting operation.

The second category of nonintegrated mills, specialty mills, includes producers of stainless steel, alloy electrical steel, tool steel, and high-temperature alloys. In addition, this category includes producers of forging ingots and a number of steel plants that produce lower volume steel products.

Overall, the nonintegrated sector of the industry consisted of about 60 companies with 91 raw-steelmaking locations.

The trend toward the use of continuous casting continued. Continuous casting production was 82.7 million tons, 89.5% of total raw steel production, compared with 76.1 million tons, 85.7% in 1993.

Data regarding U.S. production of iron and steel, and shipments of steel mill products are those reported by AISI . These data can be regarded as representing 100% of the raw steel producers in the United States.

Consumption

Shipments of steel mill products by U.S. companies were up 6.8%, to 86.3 million tons, but export shipments continued to drop; exports were down 19% from those of 1993. Shipments to domestic customers were up more than 7%. Shipments to the largest single end-use market–the automotive market–were up 16%, appliances were up 9%, service centers and distributors increased 2%, and construction products rose about 6%. Shipments of steel for containers, packaging and shipping materials increased 3%; for oil and gas drilling, mining, quarrying, and lumbering increased 8% from the 1993 level; and shipments for industrial and agricultural machinery, equipment, and tools increased 6%.

Prices

Prices for steel mill products increased steadily through 1994. On a year-to-year average basis, the Bureau of Labor Statistics' Producer Price Index for steel mill products was up by 5% in 1994 at 113.4 (1982 base=100). Price increases were announced, effective in January 1995, and the outlook was for further price increases in 1995.

Foreign Trade

Exports of steel mill products declined to 3.5 million tons, from 3.6 million tons in 1993. Canada was again the nation receiving the largest amount of U.S. exported steel, 1.9 million tons, with Mexico again in second place, receiving 0.7 million tons.

Imports of steel mill products increased to 27.3 million tons from 17.7 million tons in 1993, an increase of 54%. Brazil, Canada, the European Union (EU), Japan, Korea, Mexico, and Russia were major sources for steel mill product imports. One of the most significant developments was the emergence of Russia and Ukraine as major sources of imported steel. In 1994, over 2 million tons of steel mill products were imported from Russia and Ukraine.

A second important development in 1994 was the continued high volume of imported semifinished steel for rolling in the United States. During the period 1985 through 1992, imports of semifinished steel had been about 2 million metric tons per year. This steel, primarily in the form of slabs suitable for rolling into sheet or plate mill products, was imported and utilized mostly by companies that lack steelmaking facilities. In 1993, imports of semifinished steel increased to 4.5 million tons, and in 1994, further increased to 7.2 million tons. Almost all of the increased tonnage is believed to have been imported by companies within the steel industry itself to supplement steelmaking capacity. Excluding this major increase in imports of semifinished steel, steel mill product imports in 1994 were 20.1 million tons, an increase of 52% over that of 1993.

The increase in imports of semifinished steel by steel companies must be taken into consideration in evaluating total consumption of steel mill products in the United States and the share of the market represented by imported steel. To avoid counting both the imported semifinished steel and the products produced from it, it is necessary to subtract from domestic consumption the amount of semifinished steel consumed by companies that also produce raw steel. For 1994, this amount is estimated to have been 5 million tons. For years prior to 1993, the amount was less than 0.5 million tons per year, and for 1993, the amount of such imports was estimated to be 2.5 million tons. Taking the imported semifinished steel into consideration, the share of the U.S. steel market represented by imported steel was 26% in 1994 compared with 19% in 1993.

Regarding the reporting of imports and exports, "fabricated steel products" are products produced from steel mill products, but not including products that incorporate steel products along with other materials. Examples of fabricated steel products are fabricated structural steel and steel fasteners. "Other iron and steel products" refers to products that are not produced from steel mill products. Examples of other iron and steel products include iron or steel castings and direct-reduced iron (DRI).

World Review

World production of pig iron and DRI in 1994 totaled 540 million tons, an increase of 2% compared with that of 1993. Pig iron production, however, was up only 1%, while DRI production continued to expand rapidly, increasing 18% in the latest year and 67% over the past 5 years. Direct reduction of iron ore has proved to be a cost-effective way for developing countries, especially those with an abundance of natural gas, to encourage economic growth.

Pig iron production in most of the developed world increased about 2% to 5%, and China and India experienced double-digit growth. China is now the leading pig iron producing nation in the world, by a wide margin. A decline of 18% in the former U.S.S.R. offset increases in the rest of the world.

World production of DRI increased to almost 28 million tons in 1994, with a 17% increase in the latest year and 67% over the past 5 years. Direct reduction of iron ore has proved to be a cost-effective way for developing countries, especially those with an abundance of natural gas, to encourage economic growth.

World capacity for DRI production was estimated to be 40 million tons, with an additional 2 million tons under construction. In India, one gas-based plant and several small coal-based DRI plants were started up, bringing India's capacity for DRI to 4.8 million tons. An additional 1 million tons of capacity is under construction in India, with completion planned for 1995-97.

In Iran, about 1.8 million tons of DRI capacity was started up in 1994, bringing Iran's total capacity for DRI to 5.8 million tons.

A United States minimill company started up a gas-based direct-reduction plant in Trinidad. The plant utilizes a technology never before used in a production scale operation, and produces a unique form of direct-reduced iron in which all of the reduced iron will be in the form of iron carbide (Fe_3C), rather than in elemental form. (About 7% or 8% of the iron remains in oxide form in all direct-reduced iron products.) The resultant product, called "iron carbide," will be imported to the United States to serve as a high-quality charge material for the production of flat-rolled products in the minimills operated by the company.

World production of steel in 1994 was 726 million tons, slightly less than that of 1993. The world picture, however, was mixed, with modest growth throughout the world except in the newly independent states of the former U.S.S.R. The 12 newly independent states had combined steel production of 78 million tons, down 20% from that of 1993. As recently as 1989, the U.S.S.R. had produced more than 160 million tons of raw steel.

In the former Soviet satellite states of Eastern Europe, growth in steel production was resumed, with 1994 production of 32 million tons, an increase of 8% over that of 1993. The six nations of this region—Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovakia—had produced about 52 million tons of raw steel in 1989.

Outlook

The outlook for 1995 is for growth in world steel production of about 5% worldwide. In the former U.S.S.R., the decline appears to have been arrested, and modest growth is expected.

For the long term, little growth of steel consumption is expected in the United States or countries with highly developed economies. Steel consumption tends to expand much more slowly than overall economic growth and to contract when economic growth is weak. The outlook for the U.S. steel industry is more uncertain. Imports have tended to capture an increasing share of the U.S. market, except when restrained by such devices as the voluntary restraint agreements that were in place from 1984 through 1992. U.S. companies have made great progress in modernizing mills, adopting efficient technology, and reducing cost. With improved demand in 1994, they have been able to achieve a level of profitability that has attracted a rash of new capacity construction. New minimills, mostly to produce flat rolled steel products, will start up in 1995 through 1997, adding 5 million tons to steelmaking capacity in the United States. Some observers of the industry predict that as much as 20 million tons of new capacity will be built by about the year 2000. With expected growth in the market, new capacity will have to displace either imports or integrated production from the U.S. market.

The supply of raw material for the increased minimill production may become a problem in the United States. Although the United States traditionally has an excess supply of scrap and is a net exporter of scrap, the supply of low residual scrap necessary to produce flat-rolled steel and some other products may not be adequate. During 1994, the need for low residual material was met by a combination of imported DRI and pig iron.

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TABLE 1
SALIENT IRON AND STEEL STATISTICS 1/

(Thousand metric tons)

	1990	1991	1992	1993	1994
United States:					
Pig iron:					
Production 2/	49,700	44,100	47,400	48,200	49,400
Exports	14	15	33	27	56
Imports for consumption	347	434	497	828	2,490
Direct-reduced iron:					
Production	390	410	390	440	480
Exports	4 r/	4 r/	9 r/	15 r/	16
Imports for consumption	333 r/	365 r/	542 r/	1,090 r/	1,170
Raw steel production: 3/					
Carbon steel	78,600	70,700	74,800	78,800	81,200
Stainless steel	1,850	1,700	1,810	1,770	1,840
All other alloy steel	9,330	7,380	7,710	8,220	8,180
Total	89,700	79,700	84,300	88,800	91,200
Capability utilization, percent	84.7	74.7	82.2	89.1	93.0
Steel mill products:					
Net shipments	77,100	71,500	74,600	80,800	86,300
Exports 4/	3,900	5,760	3,890	3,600	3,470
Imports 4/	15,600	14,400	15,500	17,700	27,300
Producer price index for steel mill products 5/ (1982=100.0)	112.1	109.5	106.4	108.2	113.4
World production: 6/					
Pig iron	531,000 r/	509,000 r/	503,000 r/	506,000 r/	512,000
Direct-reduced iron	18,200	19,400	20,900	23,800	27,800
Raw steel	771,000	736,000	724,000 r/	728,000 r/	726,000 e/

e/ Esitmated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits except prices; may not add to totals shown.

2/ American Iron and Steel Institute (AISI).

3/ Raw steel is defined by AISI as steel in the first solid state after melting, suitable for rolling.

4/ Source: Bureau of the Census.

5/ Source: Bureau of Labor Statistics.

6/ Sources: U.S. Bureau of Mines and International Iron and Steel Institute.

TABLE 2
MATERIALS CONSUMED IN BLAST FURNACES AND PIG IRON PRODUCED 1/

(Thousand metric tons)

Material	1993	1994
Iron oxides: 2/		
Ores	1,960	1,820
Pellets	60,700	61,100
Sinter 3/	12,500	12,100
Total	75,100	75,100
Scrap 4/	1,920	1,800
Coke 2/	21,500	22,000
Pig iron produced	48,200	49,400

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ American Iron and Steel Institute.

3/ Includes sintered ore and pellet fines, dust, mill scale, and other revert iron-bearing materials; also some nodules.

4/ Mainly briquetted turnings and borings, shredded scrap, etc.; scrap produced at blast furnaces and remelt not included.

TABLE 3
DISTRIBUTION OF SHIPMENTS OF STEEL MILL PRODUCTS, BY STEEL TYPE, PRODUCT, AND MARKET 1/

	Thousand metric tons		Percent	
	1993	1994	1993	1994
Shipments by steel type:				
Carbon steel	75,400	80,300	93.4	93.1
Alloy steel	3,970	4,410	4.9	5.1
Stainless steel	1,390	1,560	1.7	1.8
Total shipments by steel type	80,800	86,300	100.00	100.00
Steel mill products:				
Ingots, blooms, billets and slabs	2,330	2,300	2.89	2.66
Wire rods	4,400	4,370	5.45	5.06
Structural shapes-heavy	4,510	5,000	5.59	5.79
Steel piling	389	395	.48	.46
Plates-cut lengths	4,330	4,760	5.36	5.52
Plates-in coils	2,510	3,000	3.11	3.48
Rails	498	453	.62	.52
Railroad accessories	117	119	.14	.14
Bars-hot-rolled	5,750	6,430	7.12	7.45
Bars-light-shaped	1,320	1,550	1.64	1.80
Bars-reinforcing	4,570	4,470	5.65	5.18
Bars-cold finished	1,430	1,620	1.77	1.88
Tool steel	61	60	.08	.07
Pipe and tubing-standard pipe	1,030	1,040	1.28	1.20
Pipe and tubing-oil country goods	1,190	1,210	1.48	1.40
Pipe and tubing-line pipe	745	1,030	.92	1.19
Pipe and tubing-mechanical tubing	804	939	1.00	1.09
Pipe and tubing-pressure tubing	45	35	.06	.04
Pipe and tubing-stainless	23	23	.03	.03
Pipe and tubing-structural	158	176	.20	.20
Pipe for piling	32	56	.04	.06
Wire	728	714	.90	.83
Tin mill products-blackplate	274	287	.34	.33
Tin mill products-tinplate	2,510	2,520	3.10	2.92
Tin mill products-tin-free steel	872	856	1.08	.99
Tin mill products-tin coated sheets	88	92	.11	.11
Sheets-hot-rolled	13,500	14,200	16.70	16.50
Sheets-cold-rolled	11,600	11,800	14.30	13.70
Sheets and strip-hot dip galvanized	8,810	9,930	10.90	11.50
Sheets and strip-electrogalvanized	2,940	3,340	3.64	3.88
Sheets and strip-other metallic coated	1,400	1,550	1.73	1.80
Sheets and strip-electrical	403	399	.50	.46
Strip-hot rolled	567	646	.70	.75
Strip-cold rolled	851	887	1.05	1.03
Total-steel mill products	80,800	86,300	100.00	100.00
Shipments by markets:				
Service centers and distributors	21,500	21,900	26.60	25.40
Construction	12,200	13,000	15.10	15.00
Automotive	11,500	13,400	14.30	15.50
Machinery	6,260	6,690	7.75	7.75
Containers	3,950	4,080	4.89	4.73
All others	25,300	27,200	31.30	31.60
Total shipments by market	80,800	86,300	100.00	100.00

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 4
U.S. IMPORTS AND EXPORTS OF STEEL MILL PRODUCTS, BY COUNTRY 1/

(Thousand metric tons)

Country	1993		1994	
	Imports	Exports	Imports	Exports
Argentina	131	13	200	5
Australia	398	9	398	11
Brazil	1,280	22	2,040	11
Bulgaria	11	--	198	--
Canada	4,350	1,520	4,150	1,880
China	37	78	115	41
European Union	6,190	115	8,460	119
Finland	184	--	224	3
India	119	24	188	33
Japan	1,620	94	3,220	31
Korea, Republic of	911	25	1,320	15
Mexico	767	861	1,590	734
Russia	170	32	1,600	5
Slovakia	43	--	178	--
South Africa, Republic of	368	4	431	8
Sweden	251	1	273	2
Taiwan	64	235	184	12
Trinidad and Tobago	95	21	220	6
Turkey	96	2	407	1
Ukraine	122	--	479	1
Venezuela	131	23	398	49
Other	342	519	999	506
Total	17,700	3,600	27,300	3,470

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 5
U.S. EXPORTS OF IRON AND STEEL PRODUCTS 1/

(Thousand metric tons)

	1993	1994
Steel mill products:		
Ingots, blooms, billets, and slabs	487	143
Wire rods	57	31
Structural shapes-heavy	290	326
Steel piling	6	11
Plates-cut lengths	168	139
Plates-in coils	99	123
Rails-standard	19	8
Rails-other	2	6
Railroad accessories	20	23
Bars-hot-rolled	246	248
Bars-light-shaped	59	72
Bars-concrete reinforcing	206	96
Bars-cold-finished	63	84
Tool steel	6	5
Pipe and tubing-standard pipe	37	51
Pipe and tubing-oil country goods	156	209
Pipe and tubing-line pipe	114	273
Pipe and tubing-mechanical tubing	13	13
Pipe and tubing-stainless	13	16
Pipe and tubing-nonclassified	158	177
Pipe and tubing-structural	21	33
Pipe for piling	5	2
Wire	82	90
Tin mill products-blackplate	6	5
Tin mill products-tinplate	175	189
Tin mill products-tin-free steel	64	35
Sheets-hot-rolled	136	166
Sheets-cold-rolled	328	404
Sheets and strip-hot-dip galvanized	142	130
Sheets and strip-electrogalvanized	101	54
Sheets and strip-other metallic coated	123	101
Sheets and strip-electrical	47	40
Strip-hot-rolled	42	60
Strip-cold-rolled	111	108
Total steel mill products	3,600	3,470
Fabricated steel products:		
Structural shapes-fabricated	203	215
Rails-used	35	33
Railroad products	28	35
Wire rope	8	7
Wire-stranded products	19	22
Wire-other products	22	17
Springs	27	43
Nails and staples	16	20
Fasteners	166	369
Chains and parts	21	24
Grinding balls	29	24
Pipe and tube fittings	22	21
Other 2/	34	37
Total fabricated steel products	631	866
Total all steel products	4,230	4,340
Cast iron and steel products:		
Cast steel pipe fittings	74	52
Cast iron pipe and fittings	16	25
Cast steel rolls	12	12
Cast grinding balls	16	22
Granules-shot and grit	29	32
Other castings	32	41
Total cast iron and steel products	180	183

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes shapes-cold formed, sashes and frames, fence and sign post, and architectural and ornamental work.

Source: American Iron and Steel Institute.

TABLE 6
U.S. IMPORTS OF MAJOR IRON AND STEEL PRODUCTS1/

(Thousand metric tons)

	1993	1994
Steel mill products:		
Ingots, blooms, billets and slabs	4,530	7,200
Wire rods	1,230	1,520
Structural shapes-heavy	478	662
Steel piling	66	62
Plates-cut lengths	692	1,340
Plates-in coils	549	890
Rails and railroad accessories	120	191
Bars-hot-rolled	870	1,030
Bars-light-shaped	114	116
Bars-reinforcing	109	298
Bars-cold-finished	233	272
Tool steel	80	107
Pipe and tubing-standard pipe	549	751
Pipe and tubing-oil country goods	321	310
Pipe and tubing-line pipe	467	591
Pipe and tubing-mechanical tubing	178	239
Pipe and tubing-pressure tubing	34	33
Pipe and tubing-stainless	39	44
Pipe and tubing-nonclassified	10	11
Pipe and tubing-structural	262	326
Pipe for piling	7	6
Wire	479	538
Tin mill products-blackplate	77	148
Tin mill products-tinplate	236	334
Tin mill products-tin-free steel	115	160
Sheets-hot-rolled	2,060	4,000
Sheets-cold-rolled	1,920	3,770
Sheets and strip-hot-dip galvanized	1,150	1,530
Sheets and strip-electrogalvanized	185	204
Sheets and strip-other metallic coated	133	199
Sheets and strip-electrical	104	91
Strip-hot-rolled	135	105
Strip-cold-rolled	151	194
Total steel mill products	17,700	27,300
Fabricated steel products:		
Structural shapes-fabricated	176	153
Rails-used	70	183
Railroad products	50	68
Wire rope	75	78
Wire-stranded products	122	105
Wire-other products	74	90
Springs	239	298
Nails and staples	324	337
Fasteners	730	820
Chains and parts	74	88
Pipe and tube fittings	83	90
Other	34	49
Total fabricated steel products	2,050	2,360
Total all steel products	19,700	29,600
Cast iron and steel products:		
Cast steel pipe fittings	25	28
Cast iron pipe and fittings	21	34
Other products	182	211
Total cast products	228	272

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 7
U.S. IMPORTS OF STAINLESS STEEL 1/

(Metric tons)

Product	1993	1994
Semifinished	103,000	137,000
Plate	55,600	107,000
Sheet and strip	288,000	328,000
Bars and shapes	67,800	75,600
Wire and wire rods	56,900	69,700
Pipe and tube	39,500	44,400
Total	611,000	762,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Sources: American Iron and Steel Institute.

TABLE 8
U.S. SHIPMENTS OF IRON AND STEEL CASTINGS 1/

(Thousand metric tons)

	1993 r/ 2/	1994
Ductile iron castings	3,400	3,830
Gray iron castings	8,280	9,410
Malleable iron castings	265	272
Steel castings	1,330	1,620
Steel investment castings	37	43
Total	13,300	15,200

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Data for years prior to 1993 may not be comparable due to expanded coverage of the Iron and Steel Casting Industries.

Source: Bureau of the Census.

TABLE 9
COAL AND COKE AT COKE PLANTS 1/ 2/

(Thousand metric tons)

	1993	1994
Coal: Consumption	28,400	28,800
Coke: 3/		
Production	21,000	20,600
Exports	757	599
Imports	1,390	1,460
Consumption, apparent	22,000	21,900

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Includes furnace and merchant coke plants.
3/ Coke production and consumption do not include breeze.

Source: Energy Information Administration, Quarterly Coal Report (DOE/EIA-0121).

TABLE 11
RAW STEEL: 1/ WORLD PRODUCTION, BY COUNTRY 2/ 3/

(Thousand metric tons)

Country 4/	1990	1991	1992	1993	1994 e/
Albania e/	65	35	5	5	5
Algeria	836	1,390	1,000 r/ e/	865 r/ e/	807
Angola e/	10	10	10	9	9
Argentina	3,640	2,990 r/	2,700 r/	2,870 r/	3,300
Australia	6,670	6,020	6,870	7,840 r/	8,430
Austria	4,240 r/	3,900 r/	3,600 r/	2,970 r/	4,400 5/
Azerbaijan	XX	XX	385 r/	228 r/	36
Bangladesh 6/	75	58	36	32	34
Belarus	XX	XX	1,110 r/	947 r/	873
Belgium	11,400	11,300	10,300	10,200 r/	11,200 5/
Benin e/	8	8	8	2 r/	--
Bosnia and Herzegovina e/	XX	XX	135	115	100
Brazil 7/	20,600	22,600	24,000	25,200 r/	25,700
Bulgaria	2,180 r/	1,620	1,550	1,940 r/	2,000
Canada	12,300	13,000	13,900	14,300 r/	13,900 5/
Chile 7/	772	807 r/	1,010 r/	1,060 r/	1,040
China e/	66,100	70,600	80,000	88,700	91,500
Colombia	701	652	657	687 r/	702 5/
Croatia	XX	XX	102 r/	74 r/	73
Cuba e/	255 r/	180 r/	134 r/	90 r/	80
Czech Republic	XX	XX	XX	6,730 r/	7,090
Czechoslovakia 8/	14,800	12,100	10,500	XX	XX
Denmark	610	633	591	603 r/	723 5/
Dominican Republic	36	39	33 r/ e/	-- r/	--
Ecuador	20	20	20	27 r/	22 5/
Egypt	2,240	2,540	2,500 e/	2,500 e/	2,500
El Salvador e/	21 r/	23 r/	25 r/	24 r/	24
Finland	2,860	2,890	3,080 r/	3,260 r/	3,420 5/
France	19,000	18,400	18,000	17,200	18,000 5/
Georgia	XX	XX	529 r/	215 r/	116
Germany:					
Eastern states	5,550	XX	XX	XX	XX
Western states	38,400	XX	XX	XX	XX
Total	44,000	42,200	39,700	37,600	40,800 5/
Greece	999	980	923 r/	980 r/	848 5/
Guatemala	21	23	25 r/	25 r/	24
Honduras e/	8	-- r/	-- r/	-- r/	--
Hong Kong e/	350	350	350	350	350
Hungary	2,960	1,930	1,560	1,750 r/	1,940 5/
India	15,000 r/	17,100 r/	18,100 r/	18,200 r/	18,200 5/
Indonesia	2,890	3,250	3,170	1,950 r/	2,000
Iran	1,430	2,200	2,940 r/	3,670	4,500 5/
Iraq e/	150	20	100	300 r/	300
Ireland	326	307	257	326 r/	325
Israel e/	144	160	160	160	160
Italy	25,400	25,000	24,900	25,700	26,100 5/
Jamaica e/	24	25	25	25	25
Japan	110,000	110,000	98,100 r/	99,600	98,300 5/
Jordan	179	200	244	181 r/	181
Kazakhstan	XX	XX	5,680 r/	4,280 r/	2,840
Korea, North e/	8,000	8,000	8,100	8,100	8,100
Korea, Republic of	23,100	26,000	28,100	33,000	33,700
Latvia	XX	XX	246	300	332
Libya	492	718	822	920 r/	920
Luxembourg	3,560	3,380	3,070	3,290 r/	3,090 5/
Macedonia	XX	XX	202 r/	137 r/	90
Malaysia	1,200	1,130 r/	1,560 r/	1,810 r/	1,850
Mexico	8,730	7,960 r/	8,460 r/	9,190	10,200 5/
Moldova	--	--	619 r/	604 r/	632
Morocco e/	7	7	7	7	7
Netherlands	5,410	5,170	5,440	6,000	6,170
New Zealand	719 r/	806 r/	759	853 r/	766 5/
Nigeria	133	137	140 e/	140 e/	140
Norway	383 r/	438	446	505 r/	456 5/

See footnotes at end of table.

TABLE 11--Continued
RAW STEEL: 1/ WORLD PRODUCTION, BY COUNTRY 2/ 3/

(Thousand metric tons)

Country 4/	1990	1991	1992	1993	1994 e/
Pakistan e/	1,000	1,000	1,000	1,100	1,100
Paraguay	48	61	86	86	86
Peru	284	418	338	338 e/	338
Philippines	600 r/	605 r/	497 r/	623 r/	640
Poland	13,600	10,400	9,870	9,940	11,100 5/
Portugal	744	541	749	750	720
Qatar	580	561	588	580	580
Romania	9,760	7,130 r/	5,380 r/	5,450 r/	5,570
Russia	XX	XX	67,000	58,300 r/	48,800
Saudi Arabia	1,830	1,790 r/	1,830 r/	2,320 r/	2,410
Serbia and Montenegro	XX	XX	665	183 r/	137
Singapore e/	489 5/	490	500	500	500
Slovakia e/	XX	XX	XX	3,920 r/	3,950
Slovenia e/	XX	XX	300	300	300
South Africa, Republic of	8,620	9,360	9,060	8,730 r/	8,320 5/
Spain	12,700	12,900	12,300	12,600 r/	13,600 5/
Sweden	4,450	4,250	4,360	4,590 r/	4,950 5/
Switzerland	1,110 r/	1,110 r/	1,210 r/	1,260 r/	800
Syria	76 r/	63 r/	70 e/	70 e/	70
Taiwan	9,750	11,000	10,700	12,000	11,500
Thailand	685	711	779	954 r/	1,000
Trinidad and Tobago	372	444	553	515	631 5/
Tunisia	177	193	181	190 e/	190
Turkey	9,410 r/	9,400 r/	10,300	11,500 r/	12,100 5/
Ukraine	XX	XX	41,800 r/	32,400 r/	23,800
U.S.S.R. 9/	154,000	133,000	XX	XX	XX
United Kingdom	17,900	16,500	16,200 r/	16,700 r/	17,400 5/
United States	89,700	79,700	84,300	88,800	91,200 5/
Uruguay	38	44	53	53	53
Uzbekistan	XX	XX	630 r/	573 r/	352
Venezuela	3,180	3,120	3,200	3,250	3,410 5/
Vietnam	102	103 r/	219 r/	270 r/	300
Yugoslavia 10/	3,840	2,140	XX	XX	XX
Zimbabwe	580	581	547	221 r/	180 r/
Total	771,000	736,000	722,000	728,000 r/	726,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Steel formed in first solid state after melting, suitable for further processing or sale; for some countries, includes material reported as "liquid steel," presumably measured in the molten state prior to cooling in any specific form.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Table includes data available through July 12, 1995.

4/ In addition to the countries listed, Burma, Ghana, and Mozambique are known to have steelmaking plants, but available information is inadequate to make reliable estimates of output levels.

5/ Reported figure.

6/ Data are for year ending June 30 of that stated.

7/ Excludes castings.

8/ Dissolved on Dec. 31, 1992.

9/ Dissolved in Dec. 1991.

10/ Dissolved in Apr. 1992.

TABLE 11
PIG IRON 1/ AND DIRECT-REDUCED IRON: 2/ WORLD PRODUCTION, BY COUNTRY 3/ 4/

(Thousand metric tons)

Country 5/	1990	1991	1992	1993	1994 e/
Albania e/	96 6/	50	10	10	1
Algeria	1,040	877	1,100 r/	850 r/	830 6/
Argentina:					
Pig iron	1,930 r/	1,310 r/	966 r/	986 r/	1,390 6/
Direct-reduced iron	1,040 r/	954	1,030 r/	1,160 r/	1,270 6/
Australia	6,130	5,650	6,390 r/	6,770 r/	7,470 6/
Austria	3,450	3,440	3,070	3,390 r/	3,360 6/
Belgium	9,420	9,350	8,530 r/	8,180 r/	9,030 6/
Bosnia and Herzegovina	XX	XX	150	100 e/	100
Brazil:					
Pig iron	21,100	22,700	23,200	24,000 r/	25,200 6/
Direct-reduced iron	260	226	230	240	220 6/
Bulgaria	1,140	943	837 r/	998 r/	900
Burma:					
Pig iron	3 r/	1	1 r/	2 r/	2
Direct-reduced iron e/	20	20	20	20	20
Canada:					
Pig iron	7,350	8,270	8,620	8,630	8,150 6/
Direct-reduced iron	730	553	639	758	770 6/
Chile	675	703	873 r/	917 r/	900
China	62,400	67,700 r/	75,900 r/	87,400 r/	96,400 6/
Colombia	323	305	308	238	250
Croatia e/	XX	XX	40	40	40
Czech Republic e/	XX	XX	XX	4,670 r/	5,290 6/
Czechoslovakia 7/	9,670	8,480	8,040	XX	XX
Egypt:					
Pig iron	1,100	1,250 e/	1,200 e/	1,130	1,100
Direct-reduced iron e/	710 6/	620	850	800	800
Finland	2,280	2,330	2,450	2,540 r/	2,600 6/
France	14,400	13,600	13,100	12,700 r/	13,300 6/
Georgia	XX	XX	274 r/	88 r/	--
Germany:					
Pig iron:					
Eastern states 8/	2,160	XX	XX	XX	XX
Western states	29,600	XX	XX	XX	XX
Total	31,000 r/	31,000 r/	28,500	27,000	29,900 6/
Direct-reduced iron: Western states e/	310	260	250	250	200
Hungary	1,700	1,310	1,180	1,410 r/	1,590 6/
India:					
Pig iron	12,600	14,200	15,100 r/	15,700 r/	17,300 6/
Direct-reduced iron e/	750	1,180	1,440 6/	2,210 r/ 6/	3,120 6/
Indonesia: Direct-reduced iron e/	1,300	1,350	1,400	1,400	1,620 6/
Iran:					
Pig iron	1,270	1,950	2,050	1,960	1,880 6/
Direct-reduced iron	264	470	709	1,630	2,860 6/
Iraq: Direct-reduced iron e/	170	--	--	--	--
Italy	11,900	10,900	10,500	11,100 r/	11,200 6/
Japan	80,200	80,000	73,100	73,700	73,800 6/
Kazakhstan	XX	XX	4,660 r/	3,540 r/	2,430
Korea, North e/	6,500	6,500	6,600	6,600	6,600
Korea, Republic of	15,300	18,500	19,300	22,000 e/	21,200
Libya: Direct-reduced iron e/	500	780	850	944 r/ 6/	852 6/
Luxembourg 8/	2,650	2,460	2,260	2,410 r/	1,930 6/
Macedonia	XX	XX	20	20 e/	20
Malaysia: Direct-reduced iron e/	600	600	600	600	1,000
Mexico:					
Pig iron	3,670 r/	2,960 r/	3,400	3,420	3,500 6/
Direct-reduced iron	2,530	2,460	2,390	2,740	3,220
Morocco e/	15	15	15	15	15
Netherlands 8/	4,960	4,700	4,850	5,410 r/	5,440 6/
New Zealand: Direct-reduced iron	549	594	384	406	563 6/
Nigeria: Direct-reduced iron e/	140	140	140	100	100
Norway	54	61	70 r/	73 r/	70
Pakistan e/	1,000	1,100	1,100	1,200	1,200
Paraguay	61	60	60	60 e/	60

See footnotes at end of table.

TABLE 11--Continued
PIG IRON 1/ AND DIRECT-REDUCED IRON: 2/ WORLD PRODUCTION, BY COUNTRY 3/ 4/

(Thousand metric tons)

Country 5/	1990	1991	1992	1993	1994 e/
Peru:					
Pig iron	93	207	147	147	147
Direct-reduced iron	29	24	20	20 e/	20
Poland	8,660	6,360	6,350	6,180 r/	6,800 6/
Portugal	339	251	402	398 r/	415
Qatar: Direct-reduced iron e/	530	530	530	530	530
Romania	6,360	4,530 r/	3,110	3,190 r/	3,500 6/
Russia:					
Pig iron	XX	XX	45,800 r/	40,900 r/	36,100
Direct-reduced iron e/ 9/	XX	XX	1,580	1,540 r/	1,710 6/
Saudi Arabia: Direct-reduced iron	1,090	1,120	1,610	2,000	2,110 6/
Serbia and Montenegro	XX	XX	512	500 e/	500
Slovakia e/	XX	XX	XX	3,000	3,000
South Africa, Republic of:					
Pig iron	6,260	6,970	6,500	6,120 r/	6,050 6/
Direct-reduced iron	882	863	854	833 r/	980 6/
Spain	5,540	5,400	5,080	5,450 r/	5,450
Sweden	2,740	2,810	2,740	2,850 r/	3,040 6/
Switzerland	129 r/	105 r/	110 r/	110 r/	110
Taiwan	5,470	5,560	5,290	6,120	5,940
Trinidad and Tobago: Direct-reduced iron	697	710	680	675	912 6/
Tunisia e/	140	140	140	140	140
Turkey	4,830	4,590	4,510	4,350 r/	4,600 6/
Ukraine	XX	XX	34,700 r/	27,000	20,000
U.S.S.R: 10/					
Pig iron	110,000	91,000 r/	XX	XX	XX
Direct-reduced iron e/ 9/	1,600	1,500	XX	XX	XX
United Kingdom	12,300	11,900	11,500 r/	11,500 r/	12,000 6/
United States:					
Pig iron	49,700	44,100	47,400	48,200	49,400
Direct-reduced iron	390	410	390	440	480
Venezuela:					
Pig iron	314	--	--	--	--
Direct-reduced iron	3,130 r/	4,020 r/	4,300	4,510 r/	4,710 6/
Yugoslavia 11/	2,310	1,600 e/	--	--	--
Zimbabwe e/	521	535	507	500	187
Total pig iron	531,000 r/	509,000 r/	503,000 r/	506,000 r/	512,000
Total direct-reduced iron	18,200	19,400	20,900	23,800	28,000
Grand total	549,000 r/	528,000 r/	524,000 r/	530,000 r/	540,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Production is pig iron unless otherwise specified.

2/ Direct-reduced iron is obtained from ore by reduction of oxides to metal without melting.

3/ Table excludes ferroalloy production except where otherwise noted. Table includes data available though July 12, 1995.

4/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

6/ In addition to the countries listed, Vietnam has facilities to produce pig iron and may have produced limited quantities during 1990-94, but output is not reported and available information is inadequate to make reliable estimates of output levels.

6/ Reported figure.

7/ Dissolved Dec. 31, 1992.

8/ Includes blast furnace ferroalloys.

9/ All production in the U.S.S.R. for 1990-91 came from Russia.

10/ Dissolved in Dec. 1991.

11/ Dissolved in Apr. 1992.

TABLE 12
GOVERNMENT INVENTORY OF FERROALLOYS, DECEMBER 31, 1994 1/

(Metric tons of alloy, unless otherwise stated)

Alloy	Stockpile grade	Nonstockpile grade	Total
Ferrochromium:			
High-carbon	740,000	629	740,000
Low-carbon	272,000	10,400	283,000
Ferrochromium-silicon	51,700	1,240	52,900
Ferrocolumbium (kilograms contained columbium)	385,000 2/	151,000	535,000
Ferromanganese:			
High-carbon	982,000	--	982,000
Medium-carbon	19,700	--	19,700
Ferrotungsten (kilograms contained tungsten)	385,000	533,000	918,000
Silicomanganese	183	--	183

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes 113,000 kg of material on hand but not yet applied to stockpile.

TABLE 13
U.S. FERROALLOY PRODUCTION 1/ AND SHIPMENTS 2/ 3/

(Metric tons, gross weight, unless otherwise specified)

	1994			
	Net production	Net shipments		Stocks, December 31
		Quantity	Value (thousand)	
Ferrophosphorus	W	51,500	$5,880	11,200
Ferrosilicon 4/	359,000	343,000	196,000	68,900
Silicon metal	158,000	163,000	226,000	6,360
Other 5/	267,000	223,000	245,000	35,700
Total	784,000	780,000	672,000	122,000

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Does not include alloys produced for consumption in the making of other ferroalloys.

2/ Gross sales (including exports) minus purchases.

3/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

4/ Includes all regular and specialty grades of ferrosilicon, excluding silvery pig iron.

5/ Includes ferroaluminum, ferroboron, and other complex boron additive alloys, all chromium-containing ferroalloys and chromium metal, all manganese-containing ferroalloys and manganese metal, ferromolybdenum, ferronickel, ferrotitanium, ferrovanadium, silvery pig iron, and data indicated by the symbol "W."

TABLE 14
REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ADDITIVES IN 1994, BY END USE 1/ 2/

(Metric tons of alloys unless otherwise specified)

End use	FeMn	SiMn	FeSi	FeTi	FeP	FeB
Steel:						
Carbon	277,000	83,100	60,500 3/	2,390	4,680	767
Stainless and heat-resisting	14,700 3/	4,460	65,800 3/	1,930	–	29
Other alloy	46,700 3/	24,600	52,000 3/	409	1,010	397
Tool	(4/)	(4/)	2,490 3/	(5/)	–	–
Unspecified	1,210	425	15,300	–	(5/)	(5/)
Total steel	340,000	113,000	196,000	4,720	5,690	1,190
Cast irons	10,900	605	182,000	96	1,340	(6/)
Superalloys	122 7/	–	18 8/	609	–	(6/)
Alloys (excluding alloy steels and superalloys)	21,200	(9/)	W	659	W	136
Miscellaneous and unspecified	(6/)	(9/)	207,000	(6/)	90	(6/)
Grand total	372,000	113,000	586,000	6,090	7,110	1,330
Total 1993	365,000 r/	111,000 r/	590,000 r/	5,920 r/	7,970	1,160 r/
Percent of 1993	102	102	99	103	89	115
Consumer stocks, December 31	40,100 10/	7,000 10/	20,000	575	1,150	245

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ FeMn, ferromanganese, including spiegeleisen and manganese metal; SiMn, silicomanganese; FeSi, ferrosilicon, including silicon metal, silvery pig iron, and inoculant alloys; FeTi, ferrotitanium, including other titanium materials; FeP, ferrophosphorus, including other phosphorus materials; FeB, ferroboron including other boron materials.

3/ Part included with "Steel: Unspecified."

4/ Included with "Steel: Unspecified."

5/ Included with "Steel: Other alloy."

6/ Included with "Alloys (excluding alloy steels and superalloys)."

7/ Part included with "Alloys (excluding alloy steels and superalloys)."

8/ Part included with "Miscellaneous and unspecified."

9/ Withheld to avoid disclosing company proprietary data.

10/ Includes producer stocks.

TABLE 15
REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS IN 1994, BY END USE 1/ 2/

(Metric tons of contained elements unless otherwise specified)

End use	FeCr	FeMo	FeW	FeV	FeCb	FeNi
Steel:						
Carbon	11,700	1,050	–	1,680	920	–
Stainless and heat-resisting	275,000 3/	3,890	35	26	350	17,600
Other alloy	38,700 3/	4,500	19	1,760	1,050	–
Tool	2,980	788	529	424	(4/)	–
Unspecified	609	–	–	11	9	–
Total steel	329,000	10,200	583	3,900	2,330	17,600
Cast irons	4,950	986	–	31	–	–
Superalloys	9,450 5/	618	300	16	411	–
Alloys (excluding alloy steels and superalloys)	2,560	169	5,920	326	W	–
Miscellaneous and unspecified 6/	2,980	7,090	1,310	23	9	1,290
Grand total	349,000	19,100	8,110	4,290	2,750	18,900
Total 1993	361,000 r/	17,700 r/	7,580	3,970	2,470 r/	105,000 r/
Percent of 1993	97	108	107	108	111	18
Consumer stocks, December 31	14,900 7/	2,080	849	473	NA	7,210 8/

r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ FeCr, ferrochromium, including other chromium ferroalloys and chromium metal; FeMo, ferromolybdenum, including calcium molybdate; FeW, ferrotungsten, including scheelite; FeV, ferrovanadium, including other vanadium-carbon-iron ferroalloys; FeCb, ferrocolumbium, including nickel columbium; FeNi, ferronickel.

3/ Part included with "Steel: Unspecified."

4/ Included with "Steel: Unspecified."

5/ Part included with "Alloys (excluding alloy steels and superalloys)."

6/ Includes mill products made from metal powder, pigments, catalyts and other chemicals or ceramic uses.

7/ Includes some producer stocks.

8/ Secondary stocks not yet available.

TABLE 16
FERROALLOY PRICES IN 1994

	High	Low	Average 1/
Standard-grade ferromanganese 2/	500.00	470.00	482.66
Medium-carbon ferromanganese 3/	49.00	45.00	46.98
Silicomanganese 4/	26.50	24.00	25.11
Charge-grade ferrochromium 3/	45.00	35.50	36.84
High-carbon ferrochromium 3/	48.50	34.75	36.92
Low-carbon ferrochromium 3/	90.00	70.00	83.00
50%-grade ferrosilicon 3/	45.00	42.50	43.94
75%-grade ferrosilicon 3/	45.00	35.70	40.78
Silicon metal 4/	67.00	59.00	64.06
Ferromolybdenum 5/	15.00	3.35	5.11
Molybdenum oxide 5/	17.00	2.68	4.60
Ferrovanadium 6/	18.50	7.80	9.08

1/ Annual weighted average.

2/ Dollars per long ton.

3/ Cents per pound of contained element.

4/ Cents per pound.

5/ Dollars per pound of contained element.

6/ Dollars per kilogram of contained element.

Source: Platt's Metals Week.

TABLE 17
U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 1994 1/

(Metric tons)

	Imports			Exports		
	Gross weight	Contained weight	Value (thousands)	Gross weight	Contained weight	Value (thousands)
Ferroalloys:						
Chromium ferroalloys:						
Ferrochromium containing:						
More than 4% of carbon	248,000	147,000	$94,000	6,220	3,700	$525
More than 3% but not more than 4% of carbon	4,830	2,820	1,770	XX	XX	XX
Not more than 3% of carbon	64,500	42,500	52,000	5,320	3,280	6,450
Ferrochromium-silicon	15,100	526	7,790	499	174	554
Total chromium ferroalloys	333,000	193,000	156,000	12,000	7,150	7,530
Manganese ferroalloys:						
Ferromanganese containing:						
More than 4% of carbon	249,000	194,000	99,900	XX	XX	XX
More than 2% of carbon	XX	XX	XX	4,280	(2/)	2,700
More than 1% but not more than 2% of carbon	74,400	59,900	53,500	XX	XX	XX
Not more than 1% of carbon	12,200	10,800	15,400	XX	XX	XX
Ferromanganese, other	XX	XX	XX	6,700	(2/)	6,770
Silicomanganese	273,000	181,000	123,000	6,840	(2/)	5,490
Total manganese ferroalloys	609,000	445,000	292,000	17,800	XX	15,000
Silicon ferroalloys:						
Ferrosilicon containing:						
More than 55% of silicon	XX	XX	XX	7,940	4,790	7,430
More than 55% but not more than 80% of silicon and more than 3% of calcium	2,190	1,610	1,550	XX	XX	XX
More than 55% but not more than 80% of silicon and not more than 3% of calcium	180,000	136,000	111,000	XX	XX	XX
Magnesium ferrosilicon	6,740	3,060	6,670	XX	XX	XX
Ferrosilicon, other	15,700	5,900	5,760	30,000	15,000	28,900
Total silicon ferroalloys	204,000	147,000	125,000	38,000	19,800	36,300
Other ferroalloys:						
Ferrocerium and other pyrophoric alloys	170	(2/)	1,420	XX	XX	XX
Ferromolybdenum	4,590	2,960	2,260	795	479	5,200
Ferronickel	42,400	15,300	85,500	60	35	97
Ferroniobium (columbium)	3,980	(2/)	34,000	234	(2/)	2,080
Ferrophosphorus	15,200	(2/)	5,170	29,100	(2/)	4,960
Ferrotitanium and ferrosilicon-titanium	6,340	(2/)	11,200	XX	XX	XX
Ferrotungsten and ferrosilicon-tungsten	669	515	1,890	39	19	71
Ferrovanadium	3,190	1,910	12,900	498	374	4,410
Ferrozirconium	60	(2/)	108	131	(2/)	160
Ferroalloys, other	22,400	(2/)	30,600	3,280	(2/)	4,520
Total other ferroalloys	99,000	XX	185,000	34,200	XX	21,500
Total ferroalloys	1,240,000	XX	758,000	102,000	XX	80,300
Metals:						
Chromium	6,520	(2/)	39,300	446	(2/)	4,150
Manganese:						
Unwrought	16,600	(2/)	23,000	16,600	(2/)	23,000
Other	3,630	(2/)	5,760	3,630	(2/)	5,760
Silicon:						
Less than 99% of silicon	62,400	70,600	59,900	9,240	8,970	12,600
Less than 99.99% but not less than 99% of silicon	36,900	36,400	47,500	796	773	1,110
Not less than 99.99% of silicon	1,120	1,120	44,500	2,080	2,080	127,000
Total ferroalloy metals	127,000	XX	220,000	32,800	XX	173,000
Grand total	1,370,000	XX	978,000	135,000	XX	254,000

XX Not applicable.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Not recorded.

Source: Bureau of the Census.

TABLE 18
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE 1/ 2/

(Metric tons)

Country, furnace type, 3/ and alloy type 4/	1990	1991	1992	1993	1994 e/
Albania: Electric furnace, ferrochromium e/	24,000 5/	25,000 e/	22,000 r/	36,000 r/	34,000
Argentina: Electric furnace:					
Ferromanganese	24,300	26,300	4,520	5,400 r/ e/	4,500
Silicomanganese	21,800	14,600	30,800	18,500 r/ e/	20,000
Ferrosilicon	23,600	14,400	8,070 r/	10,000 r/ e/	10,000
Silicon metal	5,930 r/	5,030 r/	3,400 r/	3,500 r/ e/	3,500
Other	380 r/	375 r/	197 r/	200 r/ e/	200
Total	76,100 r/	60,700 r/	47,000 r/	37,600 r/ e/	38,200
Australia: Electric furnace: e/					
Ferromanganese	70,000	45,000	55,000	75,000	100,000
Silicomanganese	65,000	74,000	75,000	75,000	100,000
Ferrosilicon	20,000	19,000	17,000 r/	--	--
Silicon metal	33,000	30,000	30,000	30,000	30,000
Total	188,000	168,000	177,000 r/	180,000 r/	230,000
Austria: Electric furnace: e/					
Ferronickel	8,100	8,600	6,100	6,100	6,100
Other	3,900	3,400	5,900	5,900	5,900
Total	12,000 5/	12,000	12,000	12,000	12,000
Belgium: Electric furnace, ferromanganese e/	25,000	25,000	25,000	25,000	25,000
Bosnia and Herzegovina: Electric furnace:					
Ferrosilicon	XX	XX	5,000	1,000 e/	1,000
Silicon metal	XX	XX	2,000	200 e/	200
Other	XX	XX	500	--	--
Total	XX	XX	7,500	1,200 e/	1,200
Brazil: Electric furnace:					
Ferromanganese	171,000	169,000	179,000	202,000 r/	180,000
Silicomanganese	217,000	272,000	300,000	284,000 r/	270,000
Ferrosilicon	229,000	191,000	244,000	240,000 e/	240,000
Silicon metal	132,000	106,000	93,700	95,000 e/	100,000
Ferrochromium	83,800	82,200	91,100 r/	83,900 r/	77,100
Ferrochromiumsilicon	4,970	4,520	4,500 e/	4,500 e/	5,000
Ferronickel	34,300	34,100	34,000 e/	34,000 e/	34,000
Other	68,000	76,500	76,700	76,000 r/ e/	76,000
Total	939,000	935,000	1,020,000 e/	1,020,000 r/ e/	982,000
Bulgaria: Electric furnace: e/					
Ferrosilicon	16,200	25,200	18,000	18,000	18,000
Other	1,800	2,800	2,000	2,000	2,000
Total	18,000	28,000	20,000	20,000	20,000
Canada: Electric furnace: e/					
Ferromanganese 6/	185,000 5/	45,000	--	--	--
Ferrosilicon	95,000 r/	75,000 r/	55,000	55,000	55,000
Silicon metal	20,000 r/	20,000 r/	20,000	20,000	20,000
Ferrovanadium	2,000 r/	2,000 r/	2,000	2,000	2,000
Total	302,000 r/	142,000 r/	77,000	77,000	77,000
Chile: Electric furnace:					
Ferromanganese	3,590	6,780	7,460	8,920 r/	8,500
Silicomanganese	985	1,670	1,560	1,610 r/	1,610
Ferrosilicon	4,660	5,520	5,600 e/	5,700 e/	5,600
Ferrochromium	1,870	2,510	2,100	680 r/	1,580
Ferromolybdenum	2,280	2,670	2,310 r/	2,300 r/	2,300
Total	13 400	19,200 e/	19,000 r/ e/	19 200 r/ e/	19 600
China: e/					
Blast furnace:					
Ferromanganese	330,000	500,000	550,000	520,000 r/	510,000
Other	170,000	170,000	180,000	200,000	210,000
Electric furnace:					
Ferromanganese	150,000	180,000	200,000	220,000	250,000
Silicomanganese	370,000	415,000	420,000	525,000 r/	550,000
Ferrosilicon	727,000	817,000	834,000	1,040,000 r/	1,100,000
Ferrochromium	340,000 r/	380,000 r/	410,000 r/	372,000 r/	370,000
Other	313,000 r/	88,000	56,000 r/	58,000 r/	110,000
Total	2,400,000	2,550,000	2,650,000	2,930,000 r/	3,100,000
Colombia: Electric furnace, ferronickel	43,800	49,800	49,800	44,000 r/	50,800

See footnotes at end of table.

TABLE 18--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE 1/ 2/

(Metric tons)

Country, furnace type, 3/ and alloy type 4/	1990	1991	1992	1993	1994 e/
Croatia: Electric furnace:					
Ferrochromium	XX	XX	56,500	27,300	32,000 5/
Ferromanganese e/	XX	XX	10,000	10,000	10,000
Silicomanganese e/	XX	XX	40,000	40,000	40,000
Total e/	XX	XX	106,000	77,300	82,000
Czech Republic: Electric furnace, total e/	XX	XX	XX	1,000	1,000
Czechoslovakia: Electric furnace:					
Ferromanganese e/ 6/	102,000	90,000	70,000	XX	XX
Ferrosilicon	20,500	15,000 e/	15,000 e/	XX	XX
Silicon metal e/	5,000	5,000	5,000	XX	XX
Ferrochromium	37,500 r/	41,200 r/	52,500 r/	XX	XX
Other e/ 7/	10,000	10,000	10,000	XX	XX
Total e/	175,000 r/	161,000 r/	153,000 r/	XX	XX
Dominican Republic: Electric furnace, ferronickel	71,800	72,700	68,800	62,900 r/	80,900
Egypt: Electric furnace:					
Ferrosilicon	7,920	20,000 r/ e/	36,000 r/	40,100 r/	40,000
Ferromanganese	--	10,000 r/ e/	10,000 r/	30,000 r/	35,000
Total	7,920	30,000 r/ e/	46,000 r/	70,100 r/	75,000
Finland: Electric furnace, ferrochromium	157,000	190,000	187,000	218,000	229,000 5/
France:					
Blast furnace, ferromanganese e/	315,000 r/ 5/	290,000 r/	280,000 r/	250,000	300,000
Electric furnace:					
Ferromanganese e/	36,000 5/	30,000	60,000	57,000 r/	60,000
Silicomanganese 8/	61,900	30,000 e/	80,000	80,000 e/	75,000
Ferrosilicon	117,000	106,000	98,000	39,000 r/	40,000
Silicon metal e/	64,000	64,000	60,000	59,000 r/	60,000
Ferrochromium e/	25,000	23,100	6,690	--	--
Other e/ 9/	70,000	50,000	36,000	29,000 r/	30,000
Total e/	689,000 r/	593,000 r/	621,000 r/	514,000 r/	565,000
Georgia: Electric furnace: e/					
Ferromanganese	XX	XX	100,000	100,000	50,000
Silicomanganese	XX	XX	50,000	50,000	25,000
Other	XX	XX	10,000	10,000	5,000
Total	XX	XX	160,000	160,000	80,000
Germany: e/					
Blast furnace, Western states: Ferromanganese	250,000	220,000	130,000	100,000	--
Electric furnace:					
Ferromanganese: 6/					
Eastern states	65,300 5/	XX	XX	XX	XX
Western states	38,000	XX	XX	XX	XX
Total	103,000	40,000	30,000	20,000	20,000
Ferrosilicon:					
Eastern states	24,000	XX	XX	XX	XX
Western states	46,000	XX	XX	XX	XX
Total	70,000	50,000	20,000	20,000	20,000
Silicon metal, Eastern states	3,000	2,600	500	500	500
Ferrochromium:					
Eastern states	21,000	XX	XX	XX	XX
Western states	37,500	XX	XX	XX	XX
Total	58,500	38,300 r/	26,500 5/	16,400 5/	17,000
Other: 7/					
Eastern states	12,000	XX	XX	XX	XX
Western states	54,000	XX	XX	XX	XX
Total	66,000	40,000	30,000	30,000	30,000
Grand total	551,000	391,000 r/	237,000	187,000	87,500
Greece: Electric furnace:					
Ferrochromium	30,300	10,500 e/	--	--	--
Ferronickel	60,500	64,000	65,000	45,000 e/	60,000
Total	90,800	74,500 e/	65,000	45,000 e/	60,000

See footnotes at end of table.

TABLE 18--Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE 1/ 2/

(Metric tons)

Country, furnace type, 3/ and alloy type 4/	1990	1991	1992	1993	1994 e/
Hungary: 10/ Electric furnace: e/					
Ferrosilicon	9,000	7,000	7,000	7,000	7,000
Silicon metal	2,000	1,000	1,000	1,000	1,000
Other	1,000	1,000	1,000	1,000	1,000
Total	12,000	9,000	9,000	9,000	9,000
Iceland: Electric furnace, ferrosilicon	62,800	50,300	51,700	67,400 r/	66,000 5/
India: Electric furnace:					
Ferromanganese	201,000	211,000 e/	198,000 e/	137,000 r/	150,000
Silicomanganese	57,400	70,000 e/	93,000 e/	85,000 r/	90,000
Ferrosilicon	91,600 r/	85,300 r/	90,000 r/	67,600 r/	85,000
Ferrochromium e/	169,000 r/	229,000 r/	257,000 r/	235,000 r/	251,000
Ferrochromiumsilicon	7,000	8,800	9,000 e/	8,000 e/	8,000
Other e/	400	6,770 5/	6,500	8,600 r/	8,500
Total e/	526,000 r/	611,000 r/	653,000 r/	541,000 r/	593,000
Indonesia: Electric furnace: e/					
Ferronickel	25,000 5/	25,000	26,000	27,000 r/	27,000
Ferromanganese	--	--	--	10,000	10,000
Total	25,000 5/	25,000	26,000	37,000 r/	37,000
Iran: Electric furnace, ferrochromium e/	--	--	--	--	5,000
Italy: Electric furnace:					
Ferromanganese	41,800	14,100	17,100 r/	17,000 r/ e/	16,000
Silicomanganese e/	56,000	55,000	50,000	50,000	40,000
Ferrosilicon	39,800	12,600	3,350 r/	-- r/	--
Silicon metal	13,000 e/	16,200	10,000	10,000 e/	--
Ferrochromium	53,000	47,200	60,300	53,500	22,700
Other e/ 11/	14,500	14,500	12,000	12,000	12,000
Total e/	218,000	160,000	153,000 r/	143,000 r/	90,700
Japan: Electric furnace:					
Ferromanganese	452,000	464,000	362,000	383,000	340,000 5/
Silicomanganese	77,500	87,200	96,400	64,800	68,900 5/
Ferrosilicon	62,600	62,400	37,700	29,100 r/	13,100 5/
Ferrochromium 12/	293,000	271,000	268,000	205,000 r/	192,000 5/
Ferronickel	234,000	295,000	237,000	257,000 r/	242,000 5/
Other 13/	12,100	12,300	12,200	13,700 r/	14,600 5/
Total	1,130,000	1,190,000	1,010,000	952,000 r/	871,000 5/
Kazakhstan: Electric furnace: e/					
Ferrosilicon	XX	XX	500,000	450,000	350,000
Ferrochromium	XX	XX	400,000	328,000 r/ 5/	185,000
Ferrochromiumsilicon	XX	XX	40,000	40,000	20,000
Other	XX	XX	20,000	20,000	15,000
Total	XX	XX	960,000	838,000 r/	570,000
Korea, North: Electric furnace: e/					
Ferromanganese 6/	70,000	70,000	70,000	70,000	70,000
Ferrosilicon	30,000	30,000	30,000	30,000	30,000
Other 7/	20,000	20,000	20,000	20,000	20,000
Total	120,000	120,000	120,000	120,000	120,000
Korea, Republic of: Electric furnace:					
Ferromanganese	84,000	94,900	85,900	101,000 r/	120,000 5/
Silicomanganese	82,800	74,200	82,600	82,000 r/	89,000 5/
Ferrosilicon	2,000	--	55	--	--
Total	169,000	169,000	169,000	183,000	209,000 5/
Macedonia: 14/ Electric furnace: e/					
Ferrochromium	XX	XX	3,960 5/	4,380 5/	3,160 5/
Ferrochromiumsilicon	XX	XX	1,500	--	--
Ferrosilicon	XX	XX	30,000	20,000	20,000
Silicon metal	XX	XX	1,000	1,000	1,000
Total	XX	XX	36,500	25,400	24,200
Mexico: Electric furnace:					
Ferromanganese	123,000	98,000	79,000	70,000 e/	67,000 5/
Silicomanganese	65,000	51,000	51,000	55,000 e/	64,000 5/
Ferrosilicon	7,000	6,000	5,000	400 e/	400
Ferrochromium	275	72	70 e/	-- r/	--
Other	250	105	300	300 e/	300
Total	196,000	155,000	135,000 e/	126,000 e/	132,000

See footnotes at end of table.

TABLE 18--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE 1/ 2/

(Metric tons)

Country, furnace type, 3/ and alloy type 4/	1990	1991	1992	1993	1994 e/
New Caledonia: Electric furnace, ferronickel	127,000	138,000	126,000	146,000 e/	156,000
Norway: Electric furnace:					
Ferromanganese	213,000	173,000	203,000	226,000 r/	249,000 5/
Silicomanganese	223,000	227,000	213,000	219,000 r/	197,000 5/
Ferrosilicon	398,000	377,000	367,000	400,000 r/	453,000 5/
Silicon metal e/	76,600 5/	65,000	60,000	60,000	60,000
Ferrochromium	60,000	83,000	102,000	80,000	120,000
Other e/ 8/	14,000	14,000	14,000	14,000	14,000
Total e/	985,000	939,000	959,000	998,000 r/	1,090,000
Peru: Electric furnace: e/					
Ferromanganese	1,330 r/	331 r/	-- r/	-- r/	--
Ferrosilicon	500	600	600	600	600
Total	1,830 r/	931 r/	600 r/	600 r/	600
Philippines: Electric furnace:					
Ferromanganese e/	--	5,000	5,000	5,000	5,000
Ferrosilicon e/	10,000	10,000	10,000	10,000	10,000
Ferrochromium	55,700 r/	23,700	27,400	11,900 r/	16,200
Total e/	65,700 r/	38,700	42,400	26,900 r/	31,200
Poland:					
Blast furnace:					
Spiegeleisen e/	140 5/	140	140	130	130
Ferromanganese	71,000	57,400	43,000 r/ e/	56,000 r/ e/	55,000
Electric furnace:					
Ferromanganese e/	5,400 5/	5,000	5,000	5,000	5,000
Silicomanganese e/	25,000	25,000	25,000	25,000	25,000
Ferrosilicon e/	88,600 5/	80,000	75,000	70,000	70,000
Silicon metal e/	10,000	9,000 5/	9,000	9,000	9,000
Ferrochromium	13,700	1,930	35,300 r/	38,400 r/	7,000
Other 7/	33,100	30,000	25,000 e/	20,000 e/	20,000
Total e/	247,000	208,000	217,000 r/	224,000 r/	191,000
Portugal: Electric furnace, ferromanganese e/	12,500	--	--	--	--
Romania: Electric furnace: e/					
Ferromanganese	60,000	40,000	27,100 5/	27,000	31,300 5/
Silicomanganese	30,000	30,000	28,200 5/	28,000	35,800 5/
Ferrosilicon	40,000	30,000	23,300 5/	21,000	27,900 5/
Silicon metal	4,000	1,000	430 5/	400	400
Ferrochromium	20,600	20,400	6,980 5/	3,910 5/	3,900
Total	155,000	121,000	86,000 5/	80,300	99,300
Russia: e/					
Blast furnace:					
Spiegeleisen	XX	XX	10,000	8,000	7,000
Ferromanganese	XX	XX	200,000	150,000	125,000
Ferrophosphorus	XX	XX	30,000	25,000	20,000
Electric furnace:					
Ferrosilicon	XX	XX	500,000	500,000	450,000
Silicon metal	XX	XX	60,000	60,000	50,000
Ferrochromium	XX	XX	400,000	256,000 r/ 5/	266,000 5/
Ferrochromiumsilicon	XX	XX	60,000	60,000	40,000
Ferronickel	XX	XX	65,000	50,000	45,000
Other	XX	XX	60,000	50,000	40,000
Total	XX	XX	1,390,000	1,160,000 r/	1,040,000
Serbia and Montenegro: Electric furnace:					
Ferronickel	XX	XX	6,480 r/	6 500 r/ e/	6,000
Slovakia: Electric furnace:					
Ferromanganese	XX	XX	XX	22,000 r/ e/	25,000
Silicomanganese	XX	XX	XX	12,000	12,000
Ferrochromium 15/	XX	XX	XX	50,600 r/	48,500
Other	XX	XX	XX	8,000 e/	8,000
Total	XX	XX	XX	92,600 r/ e/	93,500

See footnotes at end of table.

TABLE 18--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE 1/ 2/

(Metric tons)

Country, furnace type, 3/ and alloy type 4/	1990	1991	1992	1993	1994 e/
Slovenia: Electric furnace: e/					
Ferrochromium	XX	XX	17,100 5/	9,000 5/	12,600 5/
Ferrosilicon	XX	XX	14,000	12,000	12,000
Calciumsilicon	XX	XX	400	200	200
Other	XX	XX	5,000	--	--
Total	XX	XX	36,500	21,200	24,800
South Africa, Republic of: Electric furnace:					
Ferromanganese	404,000	260,000 r/	270,000	393,000	568,000 5/
Silicomanganese	269,000 r/	270,000 r/	267,000 r/	268,000 r/	279,000 5/
Ferrosilicon	78,200 r/	68,300	63,900 r/	98,800 r/	94,500 5/
Silicon metal	35,700 r/	39,800	34,500	38,300	36,200 5/
Ferrochromium 16/	1,020,000	1,150,000 r/	771,000 r/	834,000 r/	1,100,000 5/
Other e/	1,000	1,000	1,000	1,000	1,000
Total e/	1,810,000 r/	1,790,000 r/	1,410,000 r/	1,630,000 r/	2,080,000
Spain: Electric furnace: e/					
Ferromanganese	52,200	50,000	50,000	40,000 r/	35,000
Silicomanganese	38,400	40,000	40,000	35,000 r/	35,000
Ferrosilicon	37,500	40,000	40,000	30,000 r/	25,000
Silicon metal	9,000	9,000	10,000	5,000 r/	3,000
Ferrochromium	15,000	6,000	--	2,390 5/	2,000
Other	5,000	5,000	5,000	5,000	4,000
Total	157,000	150,000	145,000	117,000 r/	104,000
Sweden: Electric furnace:					
Ferrosilicon	18,700	21,100	15,500 r/	20,400 r/	20,000
Silicon metal	-- r/	--	--	--	--
Ferrochromium	118,000	121,000	133,000 r/	128,000	134,000 5/
Total	136,000 r/	142,000	149,000 r/	148,000 r/	154,000
Switzerland: Electric furnace: e/					
Ferrosilicon	3,000	3,000	3,000	3,000	3,000
Silicon metal	2,000	2,000	2,000	2,000	2,000
Total	5,000	5,000	5,000	5,000	5,000
Taiwan: Electric furnace:					
Ferromanganese	43,600	40,100	37,800	13,600	7,000
Silicomanganese	20,600	12,800	3,990	--	--
Ferrosilicon	15,500	6,250	2,610	689	500
Total	79,700	59,200	44,400	14,300	7,500
Thailand: Electric furnace:					
Ferromanganese	--	1,550	549	70	100
Silicomanganese	4,510	3,940	4,280	1,500	1,500
Total	4,510	5,480	4,820	1,570	1,600
Turkey: Electric furnace:					
Ferrosilicon	5,230	1,740	1,250	4,700 r/	5,000
Ferrochromium	62,000 r/	84,700	85,800	90,000	97,600 5/
Total	67,300 r/	86,400	87,000	94,700 r/	103,000
Ukraine: e/					
Blast furnace:					
Ferromanganese	XX	XX	50,000	40,000 r/	30,000
Spiegeleisen	XX	XX	5,000	4,000	3,000
Electric furnace:					
Ferromanganese	XX	XX	100,000	80,000 r/	60,000
Silicomanganese	XX	XX	1,000,000	700,000	600,000
Ferrosilicon	XX	XX	500,000	500,000	400,000
Ferronickel	XX	XX	50,000 r/	50,000 r/	38,800 5/
Other	XX	XX	40,000	40,000	30,000
Total	XX	XX	1,750,000 r/	1,410,000 r/	1,160,000
U.S.S.R.: 17/					
Blast furnace:					
Spiegeleisen	17,000	15,000 e/	XX	XX	XX
Ferromanganese	281,000	235,000	XX	XX	XX
Ferrophosphorus	30,000	31,000	XX	XX	XX

See footnotes at end of table.

TABLE 18--Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE 1/ 2/

(Metric tons)

Country, furnace type, 3/ and alloy type 4/	1990	1991	1992	1993	1994 e/
U.S.S.R. 17/--Continued:					
Electric furnace: e/ 18/					
Ferromanganese	410,000	370,000	XX	XX	XX
Silicomanganese	1,300,000	1,100,000	XX	XX	XX
Ferrosilicon	1,860,000	1,600,000	XX	XX	XX
Silicon metal	65,000	60,000	XX	XX	XX
Ferrochromium	700,000	700,000	XX	XX	XX
Ferrochromiumsilicon	100,000	100,000	XX	XX	XX
Ferronickel	85,000	80,000	XX	XX	XX
Other	160,000	140,000	XX	XX	XX
Total e/	5,010,000	4,430,000	XX	XX	XX
United Kingdom:					
Blast furnace, ferromanganese	144,000	178,000	137,000	45,000 r/ e/	--
Electric furnace, other e/	10,000	10,000	10,000	10,000	--
Total e/	154,000	188,000	147,000	55,000 r/ e/	--
United States: Electric furnace:					
Ferromanganese 19/	W	W	W	W	W
Ferrosilicon	434,000	338,000	346,000	323,000	359,000 5/
Silicon metal	141,000	145,000	159,000	159,000	158,000 5/
Ferrochromium 20/	109,000	68,300	60,900	63,000	67,400 5/
Ferronickel	7,330	14,300	18,200	9,930	-- 5/
Other	184,000	211,000	190,000	161,000	200,000 5/
Total	875,000	777,000	773,000	715,000	784,000 5/
Uruguay: Electric furnace, ferrosilicon e/	250	250	250	250	250
Venezuela: Electric furnace: e/					
Ferromanganese	--	1,000	9,000	-- r/	--
Silicomanganese	31,000	31,000	32,000	42,000 r/	40,000 5/
Ferrosilicon	55,000	55,000	56,000	56,000	41,000
Total	86,000	87,000	97,000	98,000 r/	81,000
Yugoslavia: 21/ Electric furnace:					
Ferromanganese	31,800	20,000 e/	XX	XX	XX
Silicomanganese	60,600	50,000 e/	XX	XX	XX
Ferrosilicon	103,000	80,000 e/	XX	XX	XX
Silicon metal	12,700	10,000 e/	XX	XX	XX
Ferrochromium	82,700	91,000 e/	XX	XX	XX
Ferrochromiumsilicon	4,200	3,000 e/	XX	XX	XX
Ferronickel	11,900	7,000 e/	XX	XX	XX
Calciumsilicon	835	1,000 e/	XX	XX	XX
Other	10,500	9,000 e/	XX	XX	XX
Total	318,000	271,000 e/	XX	XX	XX
Zimbabwe: Electric furnace:					
Ferrochromium	222,000	187,000	191,000	130,000 r/	190,000
Ferrochromiumsilicon	16,600	27,800	20,300	10,000 e/	10,000
Ferromanganese	--	--	--	2,150	--
Total	239,000	215,000	211,000	142,000 r/ e/	200,000
Grand total	18,800,000	17,700,000	16,800,000 r/	16,000,000 r/	16,000,000
Of which:					
Blast furnace:					
Spiegeleisen 22/	17,100	15,100	15,100	12,100	10,100
Ferromanganese 22/	1,390,000 r/	1,480,000 r/	1,390,000 r/	1,160,000 r/	1,020,000
Other	200,000	201,000	210,000	225,000	230,000
Total blast furnace	1,610,000 r/	1,700,000 r/	1,620,000 r/	1,400,000 r/	1,260,000
Electric furnace:					
Ferromanganese 23/ 24/	3,080,000	2,590,000 r/	2,270,000 r/	2,350,000	2,500,000
Silicomanganese 23/ 25/	3,080,000 r/	2,930,000 r/	2,980,000	2,740,000 r/	2,660,000
Ferrosilicon	4,780,000 r/	4,300,000 r/	4,130,000 r/	4,190,000 r/	4,070,000
Silicon metal	633,000 r/	591,000 r/	561,000 r/	553,000 r/	535,000
Ferrochromium 26/	3,750,000 r/	3,880,000 r/	3,670,000 r/	3,280,000 r/	3,490,000
Ferrochromiumsilicon	133,000	144,000	135,000	123,000	83,000
Ferronickel	708,000	788,000	753,000 r/	738,000 r/	747,000
Other	1,004,000 r/	752,000 r/	653,000 r/	601,000 r/	653,000
Total electric furnace	17,200,000	16,000,000 r/	15,200,000 r/	14,600,000 r/	14,700,000

See footnotes at end of table.

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 27, 1995.

3/ To the extent possible, ferroalloy production of each country has been separated according to the furnace type from which production is obtained; production derived from metallothermic operations is included with electric furnace production.

4/ To the extent possible, ferroalloy production of each country has been separated so as to show individually the following major types of ferroalloys: spiegeleisen, ferromanganese, silicomanganese, ferrosilicon, silicon metal, ferrochromium, ferrochromium-silicon, and ferronickel. Ferroalloys other than those listed that have been identified specifically in sources, as well as those ferroalloys not identified specifically but which definitely exclude those listed previously in this footnote have been reported as "Other." Where one or more of the individual ferroalloys listed separately in this footnote have been inseparable from other ferroalloys, owing to a nation's reporting system, deviations are indicated by individual footnotes.

5/ Reported figure.

6/ Includes silicomanganese.

7/ Includes ferrochromium-silicon and ferronickel, if any was produced.

8/ Includes silicospiegeleisen.

9/ Includes ferronickel if any was produced.

10/ Hungary is believed to produce some blast furnace ferromanganese.

11/ Series excludes calcium silicide.

12/ Includes ferrochromium-silicon.

13/ Includes calcium-silicon, ferrocolumbium, ferromolybdenum, ferrotungsten, ferrovanadium, and other ferroalloys.

14/ Imports of ferronickel originating in Macedonia were reported in 1992-94, but information on the output of the Kavadarci operation was not available.

15/ May include ferrosilicon-chromium and ferronickel, if any was produced.

16/ Includes production from Bophuthatswana. Includes net production of ferrochromium-silicon, if there was any.

17/ Dissolved in Dec. 1991.

18/ Soviet production of electric furnace ferroalloys is not reported; estimates provided are based on crude source material production and availability for consumption (including estimates) and upon reported ferroalloy trade, including data from trading partner countries.

19/ U.S. output of ferromanganese includes silicomanganese and manganese metal.

20/ U.S. output of ferrochromium includes high- and low-carbon ferrochromium, ferochromium-silicon, chromium metal, and other chromium materials.

21/ Dissolved in Apr. 1992.

22/ Spiegeleisen for the Western states of Germany is included with blast furnace ferromanganese.

23/ Ferromanganese includes silicomanganese (if any was produced) for countries carrying footnote 6 on "Ferromanganese" data line.

24/ U.S. production under "Other."

25/ Includes silicospiegeleisen for France.

26/ Ferrochromium includes ferrochromium-silicon (if any was produced) for Japan, the Republic of South Africa, and the United States.

IRON AND STEEL SCRAP

By Gerald W. Houck

Iron and steel scrap is a vital raw material for the production of new steel and cast iron products. Because of the ready availability of scrap from manufacturing operations and from the recovery of products that have reached the end of their useful lives, the steel industry and the foundry industry in the United States have been structured efficiently to recycle scrap, and, as a result, are highly dependent upon scrap.

The recycling of steel scrap plays an important role in the conservation of energy because remelting of scrap requires much less energy than the production of steel or iron products from iron ore. In addition, the consumption of iron and steel scrap by remelting reduces the burden on landfill disposal facilities and prevents the accumulation of abandoned steel products in the environment.

Consumption

Brokers, dealers, and other outside sources supplied domestic consumers in 1994 with 49 million metric tons[1] of all types of ferrous scrap at an estimated delivered value of $6.2 billion, while exporting 8.8 million tons (excluding used rails for rerolling and other uses and ships, boats, and other vessels for scrapping) valued at $1.3 billion. In 1993, domestic consumers received 46.3 million tons (revised) at a delivered value of approximately $5.2 billion (revised); exports totaled 9.81 million tons valued at $1.3 billion. For 1994, this represented a tonnage increase of about 6% for received quantities and a tonnage decrease of about 10% for exported quantities. The total value of received and exported scrap grades increased about 15%.

Raw steel production was 91.2 million tons in 1994 compared with 88.8 million tons in 1993. The shares of raw steel produced by electric and basic oxygen furnaces were, respectively, 39% and 61% in both 1994 and 1993. Continuous cast steel production represented 90% of total raw steel production in 1994 compared with 86% in 1993. Raw steel production capability was 98.1 million tons in 1994 compared with 99.7 million tons in 1993. Raw steel capability utilization was 93% in 1994 and 89% in 1993.

Net shipments of all grades of steel mill products were 86.3 million tons in 1994 and 80.8 million tons in 1993. Imports of steel mill products increased from 17.7 million tons in 1993 to 27.3 million tons in 1994. Exports of steel mill products decreased from 3.60 million tons in 1993 to 3.50 million tons in 1994. The U.S. apparent supply of steel mill products increased from 92.0 million tons in 1993 to 104.2 million tons in 1994. Imports of steel mill products, as a share of the U.S. market, increased from 19% in 1993 to 26% in 1994. Pig iron production increased from 48.2 million tons in 1993 to 49.4 million tons in 1994.

Iron castings shipments, as reported by the Bureau of the Census, totaled an estimated 13.5 million tons in 1994 compared with 11.9 million tons (revised) in 1993. Steel castings shipments (including investment castings) totaled 1.7 million tons in 1994 compared with 1.4 million tons (revised) in 1993.

In 1994, steel mills accounted for 82% of all scrap received from brokers, dealers, and other outside sources; steel foundries received 3%; and iron castings producers and miscellaneous users received 16%. The apparent total domestic consumption of ferrous scrap in 1994 was composed of 50 million tons net receipts (total receipts minus shipments) and 20 million tons of home scrap. Stocks of ferrous scrap at consumers' plants increased 11% to 4.1 million tons. The 1994 total domestic consumption was 70 million tons; in 1993, the total domestic consumption was 68 million tons (revised).

The total market for U.S. produced scrap (net receipts plus exports minus imports) was 57 million tons in 1994 compared with 54 million tons (revised) in 1993.

Domestic data for ferrous scrap were developed by the U.S. Bureau of Mines from voluntary monthly or annual surveys of U.S. scrap consuming operations. For manufacturers of pig iron and raw steel, about 91% of the known establishments responded to the surveys. Responses to surveys represented about 91% of estimated total scrap consumption by this class of consumers. The remaining 9% of scrap consumption was estimated, based on prior reports and other information. For manufacturers of steel castings and iron foundries and miscellaneous users, about 55% of the surveyed establishments responded to the annual survey, representing about 73% of estimated scrap consumption by these scrap consumers. Total consumption for these two classes of consumers was estimated using statistical methods, prior reports, and other information. Actual survey data accounted for about 80% of total estimated scrap consumption by all classes of scrap consumers.

Prices

The average composite delivered price per metric ton, calculated from prices per long ton published monthly by American Metal Market (AMM), for No. 1 heavy melting steel scrap was $126.81 in 1994, ranging from a low of $106.37 in June to a high of $136.47 in March. Calculated from prices per long ton published weekly by Iron Age Scrap Price Bulletin (IA), the average composite delivered price per metric ton of No. 1 heavy melting steel scrap was $124.58 in 1994, ranging from $104.82 in June to $135.08 in March. The average composite price for No. 1 heavy melting steel scrap in 1994 was higher than that in 1993, by 13% in both AMM and in IA.

Based on weekly quotations by IA for 18-8 (18% chromium, 8% nickel) stainless steel scrap (bundles and solids) delivered to consumers in the Pittsburgh, PA, area, the average price increased 13%, from $624 per ton in 1993 to $708 per ton in 1994.

In 1994, the average value for total ferrous scrap exports (excluding used rails for rerolling and other uses and ships, boats, and other vessels for scrapping) increased 7% to $144 per ton compared with that of 1993, while that of total imports increased

8% to $126 per ton.

Foreign Trade

Foreign trade valuation continued to be reported on f.a.s. (free alongside ship) basis for exports and on Customs value basis for imports.

The U.S. trade surplus in 1994 for all classes of ferrous scrap (including used rails for rerolling and other uses and ships, boats, and other vessels for scrapping) was $1,055 million in value and 7.1 million tons in quantity. This represented a decrease of 9% in value and 18% in quantity compared with the 1993 surplus of $1,165 million in value and 8.5 million tons in quantity.

Total U.S. exports of carbon steel and cast iron scrap (excluding used rails for rerolling and other uses; ships, boats, and other vessels for scrapping; stainless steel; and alloy steel) in 1994 went to 56 countries and totaled 8.05 million tons valued at $1,010 million for an average of $125.04 per ton. Six countries received 81% of the total quantity. The largest tonnages went to the Republic of Korea, 2.49 million tons; Canada, 1.35 million tons; Turkey, 1.18 million tons; Mexico, 618,000 tons; Japan, 494,000 tons; and India, 427,000 tons. The value of scrap exports to these six countries was $795 million, 79% of the total value.

Total U.S. exports of stainless steel scrap in 1994 went to 37 countries and consisted of 299,000 tons valued at $190 million averaging $637.00 per ton. Six countries received 86% of the total quantity. The largest tonnages went to the Republic of Korea, 76,700 tons; Spain, 70,900 tons; Canada, 49,000 tons; Japan, 25,300 tons; Sweden, 22,400 tons; and the Netherlands, 13,100 tons. The value of stainless steel scrap exports to these six countries was $164 million, 86% of the total value.

U.S. exports of alloy steel scrap (excluding stainless steel) in 1994 were shipped to 41 countries. The total comprised 462,000 tons valued at $68.5 million for an average of $148.18 per ton. Six countries received 88% of the total quantity. The largest tonnages went to Canada, 285,000 tons; Mexico, 44,700 tons; China, 27,000 tons; Italy 25,000 tons; Colombia, 13,500 tons; and the United Kingdom 9,660 tons. The value of alloy steel scrap to these six countries was $58.6 million, which was 85% of the total value.

World Review

The United States continued to be the leading exporting country of iron and steel scrap. Germany and the United Kingdom were also major exporters of ferrous scrap. Leading importing nations included Italy, Spain, Turkey, and the developing nations of Asia: China, Indonesia, India, the Republic of Korea, Taiwan, and Thailand.

Outlook

The outlook for U.S. ferrous scrap is for continued growth in demand and consumption. New electric furnace steel plants with total capacity of about 10 million tons per year were under construction in the United States, with start-ups scheduled from early 1995 through 1997. The reopening of two major electric furnace operations that were out of operation for most or all of 1994 also was expected.

Substitutes for ferrous scrap in the form of pig iron and direct-reduced iron will increase in use. The higher price of these virgin materials will be more acceptable when scrap prices are high. In addition, producers of flat-rolled steel and other products requiring low levels of residual elements in the steel increasingly will turn to iron-ore-based products to dilute the residual content that is intrinsic in scrap. However, the availability of pig iron and direct-reduced iron will not result in reduced demand for scrap; rather, it will ensure and facilitate the use of scrap by enabling its use as a greater overall proportion of the source of iron for steelmaking.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Monthly and annual publications on Iron and Steel, Iron Ore, and Iron and Steel Slag.

Other Sources

American Foundrymen's Society (AFS).
American Iron and Steel Institute (AISI).
American Metal Market.
Bureau International De La Recuperation (BIR).
Center for Materials Production (CMP).
Institute of Scrap Recycling Industries Inc. (ISRI).
International Iron and Steel Institute (IISI).
Metal Bulletin (London).
National Recycling Coalition (NRC).
Steel Can Recycling Institute (SCRI).
Steel Manufacturers Association (SMA).

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[1] All quantities are in metric tons unless otherwise specified.

TABLE 1
SALIENT U.S. IRON AND STEEL SCRAP, PIG IRON, AND DIRECT-REDUCED IRON STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
Manufacturers of pig iron and raw steel and castings: 2/					
Ferrous scrap consumption	54,000	49,000	50,000	53,000	54,000
Pig iron consumption	49,000	44,000	47,000	48,000	50,000
Direct-reduced iron consumption	690	910 r/	1,100 r/	1,500 r/	1,500
Net receipts of ferrous scrap 3/	35,000	32,000	33,000	37,000	40,000
Home scrap production 4/	19,000	17,000	17,000	16,000	14,000
Ending stocks of ferrous scrap, Dec. 31	3,400	3,400	3,100	3,200	3,600
Manufacturers of steel castings: 5/					
Ferrous scrap consumption	1,900	1,600	1,600	1,900 r/	2,000
Pig iron consumption	21	14	13	9	10
Net receipts of ferrous scrap 3/	1,300	1,100	1,100	1,300 r/	1,400
Home scrap production 4/	500	550	530	610 r/	660
Ending stocks of ferrous scrap, Dec. 31	180	160	170	86 r/	96
Iron foundries and miscellaneous users: 5/					
Ferrous scrap consumption	13,000	11,000	11,000	13,000	14,000
Pig iron consumption	840	660	620	670 r/	1,000
Direct-reduced iron consumption	18	12	11	3 r/	2
Net receipts of ferrous scrap 3/	8,900	7,600	8,000	7,900 r/	8,400
Home scrap production 4/	4,000	3,400	3,300	4,600 r/	5,100
Ending stocks of ferrous scrap, Dec. 31	730	560	520	370 r/	380
Totals, all manufacturing types:					
Ferrous scrap consumption	69,000	62,000	63,000	68,000 r/	70,000
Pig iron consumption	50,000	45,000	48,000	49,000	51,000
Direct-reduced iron consumption	710	920 r/	1,100 r/	1,500 r/	1,500
Net receipts of ferrous scrap 3/	46,000	41,000	42,000	46,000	50,000
Home scrap production 4/	23,000	21,000	21,000	22,000 r/	20,000
Ending stocks, Dec. 31:					
Ferrous scrap at consumer plants	4,300	4,100	3,800	3,700	4,100
Pig iron at consumer and supplier plants	150	190	180	220	400
Direct-reduced iron at consumer plants	89	100	130 r/	200	240
Exports: 6/					
Ferrous scrap (includes tinplate and terneplate) 7/	11,600	9,500	9,260	9,810	8,810
Value	$1,640,000	$1,230,000	$1,100,000	$1,320,000	$1,270,000
Pig iron (all grades)	14	16	33	27	56
Value	$1,620	$1,700	$3,200	$3,040	$6,780
Direct-reduced iron (steelmaking grade)	4	4	9	17	17
Value	$3,310	$2,870	$2,020	$1,860	$1,850
Imports for consumption: 6/					
Ferrous scrap (includes tinplate and terneplate) 7/	1,320	1,070	1,320	1,390 r/	1,710
Value	$172,000	$143,000	$148,000	$162,000 r/	$215,000
Pig iron (all grades)	347	434	497	828	2,500
Value	$60,100	$75,300	$72,800	$117,000	$344,000
Direct-reduced iron (steelmaking grade)	333	365	542	1,090	1,170
Value	$40,300	$40,600	$54,000	$104,000	$138,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to two significant digits, except trade data which are rounded to three significant digits; may not add to totals shown. Data are not entirely comparable due to changes in collection and estimation methods in 1993.

2/ Includes manufacturers of raw steel that also produce steel castings.

3/ Net receipts of scrap is defined as receipts from brokers, dealers, and other outside sources, plus receipts from other own-company plants, minus shipments.

4/ Home scrap production includes recirculating scrap resulting from current operations and obsolete home scrap.

5/ Some consumers in the "Manufacturers of steel castings" category also produce iron castings; some consumers in the "Iron foundries and miscellaneous users" category also produce steel castings.

6/ Source: Bureau of the Census. Export valuation is "free alongside ship" (f.a.s.) value, and import valuation is customs value.

7/ Excludes used rails for rerolling and other uses, and ships, boats and other vessels for scrapping.

TABLE 2
U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF IRON AND STEEL SCRAP IN 1994, BY GRADE 1/

(Thousand metric tons)

Grade	Receipts of scrap		Production of home scrap		Consumption of both purchased and home scrap	Shipments of scrap	Ending stocks, Dec. 31
	From brokers, dealers and other outside sources	From other own-company plants	Recirculating scrap from current operations	Obsolete scrap 2/			
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS							
Carbon steel:							
Low-phosphorus plate and punchings	350	–	1	–	340	9	23
Cut structural and plate	3,000	26	430	210	3,600	52	270
No. 1 heavy melting steel	6,500	420	3,700	18	11,000	120	720
No. 2 heavy melting steel	4,800	42	610	3	5,400	23	410
No. 1 and electric-furnace bundles	5,700	550	1,900	2	7,500	650	430
No. 2 and all other bundles	1,400	12	12	–	1,400	(3/)	87
Electric furnace, 1 foot and under (not bundles)	23	1	120	–	110	35	3
Railroad rails	130	–	37	–	180	(3/)	5
Turnings and borings	1,800	4	150	–	1,900	3	140
Slag scrap	940	110	1,400	–	2,100	360	180
Shredded or fragmentized	7,300	770	86	–	8,100	8	490
No. 1 busheling	3,400	77	120	–	3,500	84	230
Steel cans (post consumer)	220	7	–	–	220	–	8
All other carbon steel scrap	1,900	290	3,600	7	5,300	450	260
Stainless steel scrap	580	4	420	–	1,000	8	31
Alloy steel (except stainless)	210	90	530	–	820	9	62
Ingot mold and stool scrap	43	13	120	120	160	140	46
Machinery and cupola cast iron	51	–	3	(3/)	54	2	6
Cast-iron borings	200	–	1	(3/)	200	(3/)	18
Motor blocks	(4/)	–	–	–	(4/)	–	(4/)
Other iron scrap	410	42	280	(3/)	710	72	100
Other mixed scrap	850	7	420	–	1,200	87	84
Total	40,000	2,500	14,000	360	54,000	2,100	3,600
MANUFACTURERS OF STEEL CASTINGS							
Carbon steel:							
Low-phosphorus plate and punchings	340	–	66	(3/)	410	(3/)	17
Cut structural and plate	260	–	13	(3/)	270	(3/)	15
No. 1 heavy melting steel	250	11	70	(3/)	330	–	19
No. 2 heavy melting steel	12	–	31	–	43	–	1
No. 1 and electric-furnace bundles	22	–	–	–	21	–	1
No. 2 and all other bundles	–	–	–	–	–	–	–
Electric furnace, 1 foot and under (not bundles)	1	5	(3/)	–	6	–	(3/)
Railroad rails	110	–	2	–	110	–	3
Turnings and borings	43	–	11	–	54	–	1
Slag scrap	13	–	2	–	4	–	12
Shredded or fragmentized	56	–	–	–	57	–	1
No. 1 busheling	78	–	6	–	81	–	6
Steel cans (post consumer)	–	–	–	–	–	–	–
All other carbon steel scrap	120	(3/)	330	2	420	36	6
Stainless steel scrap	29	(3/)	25	–	53	(3/)	3
Alloy steel (except stainless)	63	–	87	(3/)	150	–	6
Ingot mold and stool scrap	10	–	–	–	9	–	1
Machinery and cupola cast iron	–	–	(3/)	–	(3/)	–	(3/)
Cast-iron borings	–	–	1	–	1	–	(3/)
Motor blocks	(3/)	–	(3/)	–	(3/)	–	–
Other iron scrap	9	–	9	(3/)	18	1	2
Other mixed scrap	3	(3/)	1	(3/)	4	(3/)	1
Total	1,400	17	660	3	2,000	37	96

See footnotes at end of table.

TABLE 2 --Continued
U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF IRON AND STEEL SCRAP IN 1994, BY GRADE 1/

(Thousand metric tons)

Grade	Receipts of scrap		Production of home scrap		Consumption of both purchased and home scrap	Shipments of scrap	Ending stocks, Dec. 31
	From brokers, dealers and other outside sources	From other own-company plants	Recirculating scrap from current operations	Obsolete scrap 2/			
IRON FOUNDRIES AND MISCELLANEOUS USERS							
Carbon steel:							
Low-phosphorus plate and punchings	840	1	9	(3/)	850	--	15
Cut structural and plate	1,200	31	3	(3/)	1,300	--	41
No. 1 heavy melting steel	230	5	21	--	260	2	6
No. 2 heavy melting steel	140	--	--	--	140	--	2
No. 1 and electric-furnace bundles	99	160	32	--	290	--	8
No. 2 and all other bundles	210	--	1	--	210	1	8
Electric furnace, 1 foot and under (not bundles)	140	2	2	--	140	1	3
Railroad rails	140	--	--	(3/)	140	--	7
Turnings and borings	190	99	5	--	290	4	14
Slag scrap	28	--	2	--	29	2	(3/)
Shredded or fragmentized	1,400	150	--	--	1,500	--	56
No. 1 busheling	840	140	40	--	980	40	22
Steel cans (post consumer)	23	--	--	--	23	--	(3/)
All other carbon steel scrap	120	(3/)	31	--	150	1	7
Stainless steel scrap	2	--	2	--	5	(3/)	1
Alloy steel (except stainless)	12	--	1	--	12	--	3
Ingot mold and stool scrap	61	--	96	--	180	(3/)	5
Machinery and cupola cast iron	780	24	410	(3/)	1,200	1	51
Cast-iron borings	310	110	110	1	510	9	8
Motor blocks	330	6	600	--	950	(3/)	28
Other iron scrap	300	35	3,600	--	3,900	7	66
Other mixed scrap	290	2	200	(3/)	480	1	27
Total	7,700	760	5,100	1	14,000	69	380
TOTALS FOR ALL MANUFACTURING TYPES							
Carbon steel:							
Low-phosphorus plate and punchings	1,500	1	75	(3/)	1,600	9	55
Cut structural and plate	4,500	56	450	210	5,200	52	330
No. 1 heavy melting steel	7,000	430	3,800	18	11,000	120	750
No. 2 heavy melting steel	5,000	42	640	3	5,600	23	410
No. 1 and electric-furnace bundles	5,800	710	2,000	2	7,800	650	440
No. 2 and all other bundles	1,600	12	13	--	1,600	2	94
Electric furnace, 1 foot and under (not bundles)	160	7	130	--	260	36	6
Railroad rails	380	--	39	(3/)	430	(3/)	15
Turnings and borings	2,100	100	160	--	2,300	7	160
Slag scrap	980	110	1,400	--	2,100	360	190
Shredded or fragmentized	8,800	920	86	--	9,700	8	540
No. 1 busheling	4,300	220	170	--	4,500	120	260
Steel cans (post consumer)	240	7	--	--	240	(3/)	9
All other carbon steel scrap	2,100	290	4,000	9	5,900	490	270
Stainless steel scrap	610	4	450	--	1,100	9	34
Alloy steel (except stainless)	280	90	620	(3/)	980	9	71
Ingot mold and stool scrap	110	13	210	120	350	140	52
Machinery and cupola cast iron	830	24	410	1	1,300	4	58
Cast-iron borings	510	110	110	1	700	9	26
Motor blocks	330	6	600	--	950	(3/)	28
Other iron scrap	720	77	3,900	(3/)	4,600	80	170
Other mixed scrap	1,100	10	620	(3/)	1,700	89	110
Total	49,000	3,200	20,000	360	70,000	2,200	4,100

1/ Data rounded by the U.S. Bureau of Mines to two significant digits; may not add to totals shown.

2/ Obsolete home scrap includes ingot molds, stools, and scrap from old equipment, buildings, etc.

3/ Less than 1/2 unit.

4/ Withheld to avoid disclosing company proprietary data; included in "Other iron scrap."

TABLE 3
U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF PIG IRON AND DIRECT-REDUCED IRON IN 1994 1/

(Thousand metric tons)

	Receipts	Production	Consumption	Shipments	Stocks, Dec. 31
Manufacturers of pig iron and raw steel and castings:					
Pig iron	3,700 2/	49,000	50,000	2,600	330
Direct-reduced iron	1,500 3/	W	1,500	3	240
Manufacturers of steel castings:					
Pig iron	10	--	10	--	1
Direct-reduced iron	--	--	--	--	--
Iron foundries and miscellaneous users:					
Pig iron	1,100	--	1,000	--	72
Direct-reduced iron	2	--	2	--	--
Totals for all manufacturing types:					
Pig iron	4,800	49,000	51,000	2,600	400
Direct-reduced iron	1,500	W	1,500	3	240

W Withheld to avoid disclosing company proprietary data; included in "Receipts."

1/ Data rounded by the U.S. Bureau of Mines to two significant digits; may not add to totals shown.

2/ Includes 1,400 thousand metric tons purchased by electric furnace raw steel producers.

3/ Includes 610 thousand metric tons purchased by integrated raw steel producers.

TABLE 4
U.S. CONSUMPTION OF IRON AND STEEL SCRAP, PIG IRON, AND DIRECT-REDUCED IRON (DRI) IN 1994, BY TYPE OF FURNACE OR OTHER USE 1/

(Thousand metric tons)

	Manufacturers of pig iron and raw steel and castings			Manufacturers of steel castings			Iron foundries and miscellaneous users			Totals for all manufacturing types		
	Scrap	Pig iron	DRI	Scrap	Pig iron	DRI	Scrap	Pig iron	DRI	Scrap	Pig iron	DRI
Blast furnace	1,800	--	490	--	--	--	--	--	--	1,800	--	490
Basic oxygen process	15,000	49,000	66	--	--	--	--	--	--	15,000	49,000	66
Electric furnace	37,000	1,200	940	2,000	10	--	4,700	490	--	44,000	1,700	940
Cupola furnace	--	--	--	--	--	--	8,800	520	2	8,800	520	2
Other (including air furnaces)	52	2	--	4	--	--	27	2	--	83	4	--
Direct castings 2/	--	39	--	--	--	--	--	--	--	--	39	--
Total	54,000	50,000	1,500	2,000	10	--	14,000	1,000	2	70,000	51,000	1,500

1/ Data rounded by the U.S. Bureau of Mines to two significant digits; may not add to totals shown.

2/ Includes ingot molds and stools.

TABLE 5
IRON AND STEEL SCRAP SUPPLY 1/ AVAILABLE FOR CONSUMPTION IN 1994, BY REGION AND STATE 2/

(Thousand metric tons)

Region and State	Receipts of scrap		Production of home scrap			
	From brokers, dealers, and other outside sources	From other own company plants	Recirculating scrap resulting from current operations	Obsolete scrap 3/	Shipments of scrap 4/	New supply available for consumption
New England and Middle Atlantic:						
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	81	--	25	(5/)	(5/)	110
New Jersey and New York	1,600	77	120	--	5	1,800
Pennsylvania	4,100	110	2,200	69	48	6,400
Total	5,800	180	2,300	69	54	8,300
North Central:						
Illinois	4,500	160	1,500	18	69	6,100
Indiana	3,600	180	4,600	89	590	7,900
Iowa, Nebraska, South Dakota	1,300	W	220	--	W	1,500
Kansas and Missouri	1,000	2	180	--	--	1,200
Michigan	3,200	650	2,100	(5/)	170	5,800
Minnesota	220	W	120	(5/)	W	480
Ohio	5,600	1,300	2,900	100	1,000	8,800
Wisconsin	1,200	W	940	(5/)	W	2,100
Total	21,000	2,400	12,000	210	1,900	34,000
South Atlantic:						
Delaware and Maryland	760	(5/)	560	--	56	1,300
Florida and Georgia	1,300	W	220	--	W	1,500
North Carolina and South Carolina	1,500	W	210	--	W	1,700
Virginia and West Virginia	1,500	130	540	(5/)	46	2,100
Total	5,100	130	1,500	(5/)	110	6,600
South Central:						
Alabama and Mississippi	2,600	W	990	44	W	3,500
Arkansas, Louisiana, Oklahoma	4,300	W	270	4	W	4,500
Kentucky and Tennessee	2,500	W	750	--	W	3,200
Texas	4,200	490	730	5	7	5,400
Total	14,000	510	2,700	54	130	17,000
Mountain and Pacific:						
Arizona, Colorado, Idaho, Montana, Utah	1,700	(5/)	510	W	W	2,200
California, Oregon, Washington	2,200	(5/)	280	W	W	2,400
Total	3,800	(5/)	780	30	13	4,600
Grand total	49,000	3,200	20,000	360	2,200	70,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped during the year. The difference in stock levels at the beginning and end of the year is not taken into consideration.

2/ Data rounded by the U.S. Bureau of Mines to two significant digits; may not add to totals shown.

3/ Obsolete scrap includes ingot molds, stools and scrap from old equipment, buildings, etc.

4/ Includes scrap shipped, transferred, or otherwise disposed of during the year.

5/ Less than 1/2 unit.

TABLE 6
U.S. CONSUMPTION OF IRON AND STEEL SCRAP 1/ AND PIG IRON 2/ IN 1994, BY REGION AND STATE 3/

(Thousand metric tons)

Region and State	Manufacturers of pig iron and raw steel and castings		Manufacturers of steel castings		Iron foundries and miscellaneous users		Totals for all manufacturing types	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	1,500	27	18	(4/)	410	15	1,900	42
Pennsylvania	5,400	2,800	230	3	660	88	6,300	2,900
Total	6,900	2,900	250	3	1,100	100	8,200	3,000
North Central:								
Illinois	5,200	2,800	82	1	760	44	6,000	2,900
Indiana	6,700	17,000	82	(4/)	1,400	150	8,100	17,000
Iowa, Kansas, Minnesota, Missouri, Nebraska, South Dakota, Wisconsin	2,300	7	460	2	2,500	240	5,300	250
Michigan	3,000	5,800	36	(4/)	2,800	160	5,800	6,000
Ohio	7,100	10,000	430	2	1,300	130	8,800	10,000
Total	24,000	36,000	1,100	5	8,700	720	34,000	36,000
South Atlantic:								
Delaware, Maryland, Virginia, West Virginia	2,800	5,000	2	W	490	W	3,300	5,000
Florida, Georgia, North Carolina, South Carolina	2,900	22	2	W	430	W	3,300	68
Total	5,600	5,000	4	1	920	63	6,600	5,100
South Central:								
Alabama, Kentucky, Mississippi, Tennessee	4,400	4,400	340	(4/)	1,900	85	6,700	4,500
Arkansas, Louisiana, Oklahoma	4,300	W	27	W	140	W	4,400	520
Texas	4,700	W	180	W	460	W	5,400	160
Total	13,000	5,100	550	(4/)	2,500	120	17,000	5,200
Mountain and Pacific:								
Arizona, Colorado, Idaho, Montana, Utah	2,100	W	17	(4/)	120	W	2,200	1,700
California, Oregon, Washington	2,000	W	150	(4/)	200	W	2,400	84
Total	4,100	1,700	160	(4/)	320	7	4,600	1,800
Grand total	54,000	50,000	2,000	10	14,000	1,000	70,000	51,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Includes recirculating scrap resulting from current operations and home-generated obsolete scrap.

2/ Includes molten pig iron used for ingot molds and direct castings.

3/ Data rounded by the U.S. Bureau of Mines to two significant digits; may not add to totals shown.

4/ Less than 1/2 unit.

TABLE 7
U.S. CONSUMER STOCKS OF IRON AND STEEL SCRAP AND PIG IRON, DECEMBER 31, 1994, BY REGION AND STATE 1/

(Thousand metric tons)

Region and State	Carbon steel 2/	Stainless steel	Alloy steel 3/	Cast iron 4/	Other grades of scrap	Total scrap	Pig iron
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	1	(5/)	(5/)	3	(5/)	4	W
New Jersey and New York	75	2	2	4	(5/)	83	W
Pennsylvania	340	25	26	46	4	440	25
Total	410	27	28	52	4	520	28
North Central:							
Illinois	380	W	W	16	2	400	13
Indiana	550	W	W	110	12	670	130
Iowa, Kansas, Missouri, Nebraska, South Dakota	130	(5/)	3	5	15	150	13
Michigan	130	(5/)	1	27	3	160	23
Minnesota and Wisconsin	66	1	1	10	(5/)	79	27
Ohio	320	3	17	40	6	380	29
Total	1,600	6	27	210	38	1,800	230
South Atlantic:							
Delaware, Maryland, Virginia, West Virginia	180	(5/)	W	4	W	190	W
Florida, Georgia, North Carolina, South Carolina	120	(5/)	W	25	W	150	W
Total	310	(5/)	2	28	9	350	47
South Central:							
Alabama, Kentucky, Mississippi, Tennessee	350	(5/)	W	22	W	390	W
Arkansas, Louisiana, Oklahoma	330	(5/)	W	2	W	340	W
Texas	270	(5/)	W	12	W	290	W
Total	950	1	12	37	11	1,000	78
Mountain and Pacific:							
Arizona, Colorado, Idaho, Montana, Utah	140	(5/)	1	5	--	150	W
California, Oregon, Washington	140	(5/)	1	5	49	200	W
Total	280	1	2	10	49	350	13
Grand total	3,500	34	71	330	110	4,100	400

W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Data rounded by the U.S. Bureau of Mines to two significant digits; may not add to totals shown.

2/ Excludes rerolling rails.

3/ Excludes stainless steel.

4/ Includes borings.

5/ Less than 1/2 unit.

TABLE 8
U.S. AVERAGE MONTHLY PRICE AND COMPOSITE PRICE FOR NO. 1 HEAVY MELTING STEEL IN 1994, WITH ANNUAL AVERAGES FOR 1993 AND 1994 1/

(Dollars per metric ton)

Month	Chicago	Philadelphia	Pittsburgh	Composite price
January	135.82	125.98	138.28	133.36
February	135.82	127.95	143.20	135.65
March	135.82	130.39	143.20	136.47
April	135.82	125.14	140.40	133.78
May	121.69	109.81	121.08	117.52
June	108.75	99.63	110.72	106.37
July	115.35	105.65	117.42	112.81
August	131.52	111.71	140.34	127.86
September	132.38	111.71	141.23	128.44
October	130.41	111.71	136.31	126.15
November	135.33	114.79	140.05	130.05
December	139.27	117.61	142.92	133.26
Annual average:				
1994	129.83	116.01	134.60	126.81
1993	113.44	109.40	114.46	112.44

1/ Calculated by the U.S. Bureau of Mines from prices published in American Metal Market.

TABLE 9
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY COUNTRY 1/ 2/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	Value	Quantity	Value
Belgium	11	5,870	11	6,810
Canada	1,440	172,000	1,680	209,000
China	514	82,900	447	65,500
Colombia	43	3,960	51	5,400
Germany	14	1,920	5	1,050
Greece	--	--	24	3,260
Hong Kong	171	27,900	51	11,800
India	115	14,800	435	58,400
Indonesia	6	1,130	33	5,000
Italy	16	5,640	66	9,280
Japan	537	94,000	537	84,900
Korea, Republic of	3,500	452,000	2,570	357,000
Malaysia	607	79,500	375	51,500
Mexico	610	75,900	664	82,900
Netherlands	8	3,400	22	9,960
Pakistan	128	17,600	3	1,030
Peru	44	5,490	22	2,590
Philippines	11	2,530	7	2,300
Singapore	3	1,050	3	676
South Africa, Republic of	39	3,830	6	4,360
Spain	35	18,700	71	46,300
Sweden	3	1,460	27	15,600
Taiwan	404	55,800	138	23,600
Thailand	113	16,900	120	17,400
Turkey	1,310	152,000	1,180	150,000
United Kingdom	5	1,210	27	7,430
Venezuela	69	8,550	173	22,600
Other	50 r/	10,300 r/	63	9,450
Total	9,810	1,320,000	8,810	1,270,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes used rails for rerolling and other uses, and ships, boats and other vessels for scrapping. Export valuation is "free alongside ship" (f.a.s.) value. The U.S. exported scrap to 60 countries in 1993 and 65 in 1994.

Source: Bureau of the Census.

TABLE 10
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY CUSTOMS DISTRICT 1/ 2/

(Thousand metric tons and thousand dollars)

Customs District	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Boston, MA	743	85,600	540	69,900
Buffalo, NY	90	23,300	132	33,400
Chicago, IL	19	3,190	1	195
Cleveland, OH	(3/)	3	11	1,630
Columbia - Snake	119	18,500	114	19,000
Detroit, MI	264	39,300	285	45,100
Honolulu, HI	91	11,500	109	14,700
Houston-Galveston, TX	126	46,500	68	33,800
Laredo, TX	473	58,700	352	43,400
Los Angeles, CA	1,520	219,000	1,380	202,000
Miami, FL	87	10,600	122	14,900
New Orleans, LA	208	46,300	79	50,600
New York, NY	1,600	194,000	1,600	225,000
Norfolk, VA	254	31,800	165	15,800
Pembina, ND	537	57,100	580	67,300
Philadelphia, PA	707	84,700	427	53,500
Portland, ME	287	32,500	298	38,100
Providence, RI	373	46,400	358	44,500
San Francisco, CA	823	125,000	873	135,000
Seattle, WA	389	55,200	330	50,300
Tampa, FL	337	39,900	151	19,700
Other	757	87,500	840	88,100
Total	9,810	1,320,000	8,810	1,270,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes used rails for rerolling and other uses, and ships, boats and other vessels for scrapping. Export valuation is "free alongside ship" (f.a.s.) value.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 11
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY CLASS 1/ 2/

(Thousand metric tons and thousand dollars)

Class	1993 Quantity	1993 Value	1994 Quantity	1994 Value
No. 1 heavy melting scrap	1,910	228,000	1,900	245,000
No. 2 heavy melting scrap	694	78,900	723	88,500
No. 1 bundles	186	24,300	117	15,100
No. 2 bundles	256	26,300	218	23,400
Shredded steel scrap	2,770	341,000	2,330	307,000
Borings, shovelings and turnings	162	14,200	222	21,500
Cut plate and structural	542	71,900	371	50,100
Tinned iron or steel	109	19,900	82	16,900
Remelting scrap ingots	2	612	2	1,300
Stainless steel scrap	238	147,000	299	190,000
Other alloy steel scrap	340	63,300	462	68,500
Other steel scrap 3/	1,020	124,000	878	98,700
Iron scrap	1,580	175,000	1,210	139,000
Total	9,810	1,320,000	8,810	1,270,000
Ships, boats, and other vessels for scrapping	162	13,200	106	9,420
Used rails for rerolling and other uses 4/	43	11,800	35	8,900
Total exports	10,000	1,340,000	8,950	1,280,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Export valuation is "free alongside ship" (f.a.s.) value.

3/ Includes tinplate and terneplate.

4/ Includes mixed (used plus new) rails. See Table 15 for details.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY COUNTRY 1/ 2/

(Thousand metric tons and thousand dollars)

	1993		1994	
Country	Quantity	Value	Quantity	Value
Bahamas, The	(3/)	8	(3/)	18
Belgium	(3/)	31	30	3,960
Brazil	9	559	27	1,760
Canada	1,160	129,000	1,340	164,000
China	3	362	(3/)	22
Colombia	(3/)	94	(3/)	65
Costa Rica	(3/)	10	2	187
Dominican Republic	(3/)	20	(3/)	6
France	(3/)	12	3	333
Germany	2	686	2	675
Israel	(3/)	31	--	--
Jamaica	10	976	5	486
Japan	43	4,970	61	8,290
Korea, Republic of	--	--	(3/)	3
Lithuania	2	217	--	--
Mexico	93	17,900	116	22,500
Netherlands	(3/)	239	2	1,260
Panama	(3/)	4	2	158
Philippines	--	--	(3/)	2
Poland	--	--	13	1,590
Russia	--	--	13	1,470
Singapore	(3/)	2	1	62
Sweden	(3/)	201	--	--
Switzerland	(3/)	32	(3/)	35
Trinidad and Tobago	(3/)	93	(3/)	40
Ukraine	1	581	--	--
United Kingdom	1	229	(3/)	136
Venezuela	66 r/	5,440 r/	81	6,590
Other	(3/)	184	12	1,220
Total	1,390 r/	162,000 r/	1,710	215,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes used rails for rerolling and other uses and ships, boats and other vessels for scrapping. Import valuation is customs value. The U.S. imported scrap from 34 countries in 1993 and 40 in 1994.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY CUSTOMS DISTRICT 1/ 2/

(Thousand metric tons and thousand dollars)

Customs District	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Baltimore, MD	49	1,590	29	1,880
Buffalo, NY	215	27,300	294	42,500
Charleston, SC	(3/)	(3/)	2	316
Chicago, IL	16	1,380	23	2,210
Cleveland, OH	61	5,460	56	5,910
Detroit, MI	533	60,700	679	80,000
El Paso, TX	21	3,090	17	2,490
Laredo, TX	57	11,700	82	17,000
New Orleans, LA	19 r/	2,280 r/	109	11,800
New York, NY	1	187	2	958
Ogdensburg, NY	22	5,310	25	4,530
Pembina, ND	6	1,150	4	1,360
San Diego, CA	17	3,160	19	3,130
Seattle, WA	343	32,900	338	34,100
Other	28	5,580	30	6,310
Total	1,390 r/	162,000 r/	1,710	215,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes used rails for rerolling and other uses, and ships, boats and other vessels for scrapping. Import valuation is customs value.

3/ Revised to zero.

Source: Bureau of the Census.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY CLASS 1/ 2/

(Thousand metric tons and thousand dollars)

Class	1993 Quantity	1993 Value	1994 Quantity	1994 Value
No. 1 heavy melting scrap	40	4,440	52	6,110
No. 2 heavy melting scrap	3	252	22	2,600
No. 1 bundles	126	12,800	148	16,300
No. 2 bundles	13	1,300	19	2,020
Shredded steel scrap	80	10,400	84	10,800
Borings, shovelings and turnings	71	6,210	117	10,100
Cut plate and structural	43	4,030	107	7,880
Tinned iron or steel	13	1,420	9	1,410
Remelting scrap ingots	37 r/	6,010 r/	36	6,960
Stainless steel scrap	49	20,200	43	20,200
Other alloy steel scrap	200	23,500	182	24,900
Other steel scrap 3/	632	61,100	748	85,600
Iron scrap	84	10,100	145	19,600
Total	1,390 r/	162,000 r/	1,710	215,000
Ships, boats, and other vessels for scrapping	(4/) r/	82	(4/)	210
Used rails for rerolling and other uses	70	13,600	183	31,500
Total imports	1,460 r/	175,000 r/	1,890	246,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Import valuation is customs value.

3/ Includes tinplate and terneplate.

4/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 15
U.S. EXPORTS OF USED RAILS FOR REROLLING AND OTHER USES, BY COUNTRY 1/ 2/

Country	1993 Quantity (metric tons)	1993 Value (thousand dollars)	1994 Quantity (metric tons)	1994 Value (thousand dollars)
Brazil	72	60	155	147
Canada	10,400	4,230	891	395
Chile	473	195	134	97
Germany	23	20	11	10
Guatemala	3	3	483	97
Mexico	29,900	6,600	31,500	7,240
Panama	--	--	3	9
Taiwan	1,090	184	45	13
Other	627	470	1,350	887
Total	42,500	11,800	34,600	8,900

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Exports contain mixed (used plus new) rails totaling 7,140 metric tons valued at $4,240,000 in 1993 and 1,380 metric tons valued at $1,180,000 in 1994. Export valuation is "free alongside ship" (f.a.s.) value.

Source: Bureau of the Census.

TABLE 16
U.S. IMPORTS FOR CONSUMPTION OF USED RAILS FOR REROLLING AND OTHER USES, BY COUNTRY 1/ 2/

Country	1993 Quantity (metric tons)	1993 Value (thousand dollars)	1994 Quantity (metric tons)	1994 Value (thousand dollars)
Canada	70,000	13,500	58,600	11,500
France	--	--	18	11
Germany	(3/)	2	7,130	3,930
Japan	--	--	315	290
Korea, Republic of	82	42	--	--
Mexico	--	--	6	11
Nicaragua	--	--	4,400	438
Poland	--	--	40,100	5,750
Russia	--	--	72,900	9,520
United Kingdom	--	--	42	72
Total	70,100	13,600	183,000	31,500

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Import valuation is customs value.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 17
U.S. EXPORTS OF DIRECT-REDUCED IRON (DRI), BY COUNTRY 1/ 2/

Country	1993		1994	
	Quantity (metric tons)	Value (thousand dollars)	Quantity (metric tons)	Value (thousand dollars)
Argentina	503	111	1,820	193
Aruba	484	51	--	--
Brazil	4,970	527	3,400	359
Canada	974	103	480	51
Germany	37	4	667	71
Ghana	83	9	--	--
Hong Kong	--	--	161	17
Japan	88	9	409	43
Korea, Republic of	726	97	25	3
Mexico	4,970	526	6,700	710
Taiwan	623	67	975	101
Venezuela	2,900	307	224	24
Other countries	441	49	2,590	275
Total	16,800	1,860	17,500	1,850

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Data are for steelmaking grade DRI only.

Source: Bureau of the Census.

TABLE 18
U.S. IMPORTS FOR CONSUMPTION OF DIRECT-REDUCED IRON (DRI), BY COUNTRY 1/ 2/

Country	1993		1994	
	Quantity (metric tons)	Value (thousand dollars)	Quantity (metric tons)	Value (thousand dollars)
Canada	18	2	122	19
France	1,300	137	--	--
Japan	10,500	942	--	--
Russia	70,100 r/	6,580 r/	26,600	2,860
Sweden	993	105	--	--
Venezuela	1,010,000 r/	96,400 r/	1,140,000	135,000
Total	1,090,000 r/	104,000 r/	1,170,000	138,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Data are for steelmaking grade DRI only.

Source: Bureau of the Census.

TABLE 19
U.S. EXPORTS OF PIG IRON, BY COUNTRY 1/ 2/

Country	1993 Quantity (metric tons)	1993 Value (thousand dollars)	1994 Quantity (metric tons)	1994 Value (thousand dollars)
Australia	185	16	--	--
Bermuda	--	--	210	18
Canada	1,240	245	4,970	1,010
China	162	14	--	--
Costa Rica	275	24	--	--
Germany	--	--	569	50
Ghana	102	25	--	--
Hong Kong	--	--	455	40
Japan	138	12	5,200	458
Korea, Republic of	--	--	57	5
Mexico	23,900	2,550	43,900	5,060
Netherlands	57	22	222	19
Singapore	854	75	36	3
Taiwan	164	32	--	--
United Kingdom	--	--	78	7
Venezuela	--	--	515	42
Other	35	17	146	58
Total	27,100	3,040	56,400	6,780

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes the following grades of pig iron: less than or equal to 0.5 percent phosphorus content; greater than 0.5 percent phosphorus content; and alloy grade. Export valuation is "free alongside ship" (f.a.s.) value.

Source: Bureau of the Census.

TABLE 20
U.S. IMPORTS FOR CONSUMPTION OF PIG IRON, BY COUNTRY 1/ 2/

Country	1993 Quantity (metric tons)	1993 Value (thousand dollars)	1994 Quantity (metric tons)	1994 Value (thousand dollars)
Brazil	393,000	55,200	1,230,000	175,000
Canada	61,900	13,800	64,100	16,400
Estonia	--	--	32,500	3,630
Japan	26,300	5,330	47,800	6,390
Latvia	67,100	7,650	49,000	5,840
Lithuania	10,000	790	8,060	1,060
Mexico	89	15	--	--
Russia	155,000	16,000	678,000	84,100
South Africa, Republic of	69,600	11,400	66,600	11,800
Switzerland	11,000	886	--	--
Ukraine	34,300	5,650	324,000	40,000
Total	828,000	117,000	2,500,000	344,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes the following grades of pig iron: less than or equal to 0.5 percent phosphorus content; greater than 0.5 percent phosphorus content; and alloy grade. Import valuation is customs value.

Source: Bureau of the Census.

IRON ORE

By William S. Kirk

Iron ore is essential to the economy and national security of the United States. As the basic raw material from which iron and steel is made, its supply is critical to any industrial country. Scrap is used as a supplement in steelmaking, but is limited as a major feed material because there is a limited quantity of high-quality scrap.

It was a good year for the domestic iron ore industry although consumption rose only slightly. Production and shipments also rose from 1993 levels. The increases were attributed to a 2.8% increase in crude steel production. Australia and Brazil continued to be the leading exporters of iron ore with a combined total of close to 60% of the world total.

Production

U.S. production data for iron ore are developed by the U.S. Bureau of Mines from two separate, voluntary surveys of domestic operations. The annual "Iron Ore" survey (1066-A) provides the basic data used in this report. Of 27 addressees to whom the 1066-A form was sent, 8 were inactive. The 19 others represent 100% of total production shown in tables 1 through 4. In past years, production for nonrespondents to the annual survey was estimated from monthly surveys (1066-M), from railroad reports, or from reported production levels in prior years. This information may be supplemented by employment data, mine inspection reports, and information from consumers. The American Iron Ore Association (AIOA) provided data on ore shipments from loading docks on the upper Great Lakes as well as receipts at transfer docks and furnace yards nationwide. The dock and steel plant data were compiled jointly by AIOA and the American Iron and Steel Institute (AISI).

Strikes closed four mines in Minnesota and Michigan in 1993. One of them, National Steel Pellet Co. (NPSC), remained closed though much of 1994. After being closed for nearly a year and following lengthy negotiations, National opened on August 29. Many of the company's conditions for reopening the plant centered on the reduction of production costs. Although the labor contract at Eveleth Mines expired simultaneously with those of the other producers, August 1, 1993, its workers stayed on the job, working under the terms of the expired contract. Eveleth workers, by a 517-46 vote, ratified a labor contract on February 1, 1994, retroactive to early January.

Although iron ore was produced by 16 companies, 9 of them accounted for 98.8% of all domestic production. The 16 companies operated 16 mining operations, 10 concentration plants, and 10 pelletizing plants. Of the 16 mining operations, 15 were open pit and 1 was an underground operation. Virtually all ore was concentrated before shipment, and 98.6% was pelletized.

Combined United States and Canadian production represented about 9.5% of the world output of usable ore in 1994. At least 50 countries mined crude ore during the year. The leading producer was Brazil, which accounted for 24.4% of world output in terms of metal content, followed by Australia with 18.1%. Trends in world mine production since 1990 are shown on a country basis in table 17.

Domestic iron ore production, at 58.4 million metric tons (Mmt), was 4.9% higher than that of the previous year. Productivity for usable ore in the Lake Superior District improved as usual. Eleven mines produced ore for the iron and steel industry, while the remainder shipped ore mainly to cement plants. An average of 3.3 mt of crude ore was mined in 1994 for each mt of usable ore produced. This does not include the quantity of waste rock or overburden removed. When the quantity of crude ore is added to that of overburden and waste rock, the ratio of total materials moved to usable ore produced was 5.6:1. Low-grade ores of the taconite type mined in Michigan and Minnesota accounted for 99.7% of total crude ore production. U.S. production of pellets totaled 57.5 Mmt. The average iron content of usable ore produced was 63.0%.

Michigan.—Michigan accounted for 23.8% of the national output of usable ore in 1994. All of the State's production was from the Empire and Tilden Mines near Ishpeming in Marquette County and nearly all was pelletized. Both mining ventures are managed by Cleveland Cliffs Inc.'s (Cliffs) Cleveland-Cliffs Iron subsidiary.

Cliffs increased its ownership interest, effective January 1, in the Tilden Magnetite Partnership from 33.3% to 40%. This was part of a restructuring and simplification of the operating agreement covering the Tilden Mine near Ishpeming, MI. The interests of the other two partners were reduced, with Algoma Steel Inc. changing from 50% to 45% and Stelco Inc. from 16.7% to 15%. In the new agreement, tonnage entitlements and cost-sharing were based on a 6.1-million-metric-ton-per-year (Mmt/a) target normal production level replacing the former 4 Mmt/a.

Minnesota.—Minnesota produced 75.4% of the national output of usable ore in 1994. All of the State's production came from open pit mines on the Mesabi Range. Production of pellets totaled 43.8 Mmt.

Cyprus Amax Minerals Co. sold its iron ore operation, Cyprus Northshore Mining Corp., to Cleveland-Cliffs Inc. on September 30. Specifically, Cliffs Minnesota Minerals Co., a subsidiary of Cliffs, purchased Cyprus Northshore Mining Corp. and Cyprus Silver Bay Power Corp. The mining operation was renamed Northshore Mining Co., and its power subsidiary was renamed Silver Bay Power Co. The principal assets acquired were 4.0 million tons per year (mt/a) of active iron ore pellet capacity supported by 6.0 mt/a of concentrate capacity, a 115-megawatt power generation plant, all at the E. W. Davis pelletizing plant near Silver Bay, MN, and leases on an estimated 1.2 billion tons of reserves, at the Peter Mitchell Mine, near Babbitt, MN, on the eastern Mesabi Iron Range.

Eveleth Mines reopened one of its two pellet production lines. The number one line, which last operated in 1990, resumed operations on or about May 23d. The line had a production capacity of 2 Mmt/a; the other has a capacity of 4 Mmt/a.

Auburn Minerals LLC reopened the Auburn Mine, north of Eveleth, MN, and made its first ore shipment on August 9th. Auburn Minerals was a joint venture between Premier Aggregates Inc., of Virginia, MN, and Edward Kraemer & Sons Inc., of Plain, WI.

Missouri.—The Pea Ridge Iron Ore Co. produced iron oxide powder at its mining complex near Sullivan, MO. The company has the only active underground iron mine in the country. In January 1991, the company ceased pellet production and began concentrating on specialty iron oxide products, which had formerly been coproducts.

Consumption

Data on consumption and stocks of iron ore and agglomerates at iron and steel plants were provided by the AIOA. Data on consumption of iron ore for nonsteel end uses were compiled from information gathered from other Bureau surveys. Virtually all iron ore (>98%) is consumed by the steel industry.

Iron ore consumption in 1994 rose by less than 1%. Demand failed to match increases in the apparent supply and net shipments of steel mill products because the source of material for much of the increases was imports of semifinished steel. The apparent supply of steel mill products rose 17.3%, while net shipments rose 9.1%. Net imports of semifinished steel were 9.1% greater than in 1993. Crude steel production, on the other hand, rose by only 2.8% and pig iron production, the most direct indicator of iron ore consumption, grew by only 2.5%.

Consumption of iron ore for ironmaking and steelmaking totaled 71.5 Mmt compared with 69.9 in 1993. Monthly consumption of pellets, direct-shipping ore, and merchant sinter by the industry averaged 5.96 Mmt.

U.S. production of hot metal and pig iron totaled 49.4 Mmt, a 2.5% increase from that of 1993. During 1994, the number of blast furnaces in operation ranged from 40 to 42.

Consumption of iron ore and all types of agglomerates reported to the AISI by integrated producers of iron and steel totaled 75.2 Mmt. This included 61.2 Mmt of pellets; 1.2 Mmt of sinter, briquettes, etc.; and 1.8 Mmt of natural coarse ore. Of the primary ore consumed, 79% was of domestic origin, 10% came from Canada, and 11% came from other countries. Other materials consumed in sintering plants included mill scale, flue dust, limestone and dolomite, slag and slag scrap, and coke breeze. Other iron-bearing materials charged to blast furnaces included steel-furnace slag, mill scale, and slag scrap.

The U.S. steel industry accounted for 98.7% of domestic iron ore consumption in 1994.

Prices

Most iron ore prices are negotiated between buyer and seller. About 80% of domestic ore is produced by captive mines (mines producing for company smelters) and therefore does not reach the open market. The average f.o.b. mine value of usable ore shipped in 1994 was $27.44 per ton, slightly higher than that of 1994. This average value was based primarily on producers' statements and should approximate the average commercial selling price less the cost of mine-to-market transportation.

Foreign Trade

U.S. exports of iron ore were 1.7% lower than those of 1993. Virtually all exports consisted of pellets and concentrates shipped via the Great Lakes to Canadian steel companies that are partners in U.S. taconite projects in Michigan and Minnesota. U.S. imports of iron ore rose 24.0% to 17.5 Mmt.

Net imports averaged 11.2 Mmt from 1989 through 1994, 1994 net imports were 12.5 Mmt, equivalent to 14.5% of U.S. ore consumption, up from 14.1% in 1993. Canada's share of imports was 57.7%; Brazil's was 20.7%.

World Review

At least 50 countries mined iron ore during the year, producing a total of 995 Mmt.

Australia was the leading exporter of iron ore, shipping 126.2 Mmt to world markets, followed closely by Brazil, which exported 125.0 Mmt. Together, the two countries accounted for 59.3% of exports in 1994. The next largest exporter was Canada, at 8.1%. Total exports were 422.5 Mmt, up from 397.2 Mmt in 1993. Australia's principal customer, Japan, accounted for about 45.4% of its exports with Asia as a whole accounting for 80.2%. Brazil's primary export customers were Western Europe (43.1%) and Asia (40.9%).

Australia.—The country continued to be the world's leading exporter of ore in 1994.

Hamersley Iron Pty. Ltd. opened its Marandoo Mine in October. The US$295 million mine in the central Pilbara region of Western Australia was expected to produce 8 Mmt of ore in 1995 and reach full capacity of 12 Mmt in 1996. The mine was linked by a 55-kilometer (34-mile) spur to Hamersley's main railway line to the coastal port of Dampier. Reserves reportedly were estimated at 370 Mmt with an iron content of 62.3%. Production was to be a mix of lump ore and fines with the ore being railed to Dampier for blending with ores from Hamersley's other operations.

Brazil.—Cia. Vale do Rio Doce (CVRD) completed a $25 million expansion of its Ponta de Madeira port in Maranhao State, increasing the shipping capacity from 35 to 50 Mmt/a of iron ore. The expansion enabled the port, which serves the Carajas Mine, to accommodate two large vessels at once.

Mineracoes Brasileiras Reunidas S.A. (MBR) MBR, the country's second largest iron ore producer after CVRD, inaugurated the expansion of its Pico do Itabirita Mine. The $240 million expansion increased the capacity of the mine in Minas Gerais State from 3.5 to 11 Mmt/a and increased MBR's total iron ore production capacity to 30 Mmt/a.

CVRD expanded its Ponta de Madeira port at Sao Luis by adding a second loading pier. This increased the loading capacity at the port from 35 to 50 Mmt/a.

S.A. Mineracao da Trindade (Samitri) completed an $80 million upgrade that enabled it to offer a new range of products and increase its production capacity. The main addition was a new concentrator in the State of Minas Gerais that allowed Samitri to pump as much as 1.4 Mmt/a of pellet feed into the slurry pipe of its subsidiary Samarco Minerales SA. This new tonnage was largely responsible for the rise in Samarco's capacity to 9.6 Mmt/a. The new concentrator also allowed the company to offer a new product to the direct reduced iron (DRI) market with an iron content of 68.1%. Much of the expansion work was done at the Corrego de Meio Mine, which was reopened in 1992. The 1.2 Mmt/a production from Corrego de Meio was used mainly for blending into Samitri's two new sinter feeds, one from the Morro Agudo Mine and the other from Algeria.

China.—Taiyuan Iron & Steel Co. opened a new iron mine. The Jianshan Mine, about 100 kilometers (km) (60 miles) west of Taiyuan, was expected to produce 4 Mmt/a of ore. Reserves were estimated at 158 Mmt.

Iran.—The National Iranian Steel Co. (Nisco) awarded a $100 million contract to a consortium of European firms to double the size of its Chogart Mine. The mine was producing 3 Mmt/a of lump ore grading about 56% iron. A new concentrator being installed at the mine was expected to produce 3.2 Mmt/a of concentrates grading 65% iron. A new mine, the Se Chahun, was being developed about 30 km (19 miles) away. After the concentrator was ready, ore from the new mine was to be railed to Chogart for processing. Reserves at Chogart were estimated at 70 Mmt of high-grade ore while Se Chahun reportedly had estimated reserves of 100 Mmt of medium-grade ore. The opening of the 5 Mmt/a Chador Malu Mine, which was expected in 1995, was delayed to 1997.

Mauritania.—Societe Nationale Industrielle et Miniere (SNIM) opened the M'Haoudat iron mine in northeast Mauritania.

Mexico.—Grupo Acero del Norte (GAN) reopened its Cerro de Mercado Mine in Durango after an 8-year shutdown. The company was expecting a production rate of 5,000 metric tons of iron ore per day.

Sweden.—Luossavaara Kiirunavaara AB (LKAB) was in the early stages of implementing a massive project to expand and upgrade its Kiruna operation. Of the $550 million that LKAB was investing in its iron ore facilities, $500 million had been or was to be spent at Kiruna alone. These investments were intended to provide the state-owned mine with more production capacity and extend its life.

A major portion of the investments was for deepening the mine to construct a new main haulage level that was to extend the life of the mine a further 20 years by providing access to an additional 300 Mmt of ore. The company also was investing in a new concentrator for pellet feed production and a new pelletizing plant.

Ukraine.—The Poltkij GOK combine bought a new crusher/conveyor system to increase the production capacity of its Komsomolsk Mine from 18 to 24 Mmt/a. The equipment was expected to be commissioned in the fall of 1995.

Venezuela.—CVG Ferrominera del Orinoco CA (Ferrominera) started its new 3.3 Mmt/a pellet plant at Puerto Ordaz.

Technology

LTV Steel Mining Co., Hoyt Lakes, MN, began operating a new $5.6 million super pocket in May. Pockets, devices used to transfer crude ore from haulage trucks to train cars, were an integral part of LTV's system of moving crude ore from its pits to its processing plant. The super pocket improved productivity by reducing the amount of time required for haulage trucks to dump their ore and to load the trains.

Outlook

At present consumption rates, known world iron reserves are sufficient to meet world demand well beyond the 21st century.

The domestic iron ore industry is totally dependent on the steel industry for sales. This dependence is not expected to change in the near future. Because of this relationship, the reader is referred to the outlook section in the "Iron and Steel" chapter. It is difficult for the United States to compete elsewhere in the world iron ore market because of the country's declining ore grades, the inland location of its mines, and high labor and energy costs. Only 8.1% of the iron ore produced from 1989 through 1994 was exported, with virtually all of it being pellets going to steelworks in Ontario.

For the near term, growth of the U.S. iron ore industry is tied to the growth of the integrated steelworks along the Great Lakes. The hope for the domestic iron ore industry is that one or more of the new direct processes will prove to be economic for lake producers. If this occurs, the domestic industry can supply the rapidly expanding mini-mill sector of the steel industry. Electric arc furnaces currently account for more than one-third of total crude steel production. Because of advances in steelmaking, steel products now require lower residual alloy content than can be readily achieved with scrap. This indicates a role for imported DRI in the coastal regions of the United States. The growth of gas-based DRI production capacity outside North America has been spectacular in recent years. Although a large part of this growth has occurred in Venezuela, the bulk of the construction has been spread evenly through a variety of countries that have surplus natural gas. It is too early to tell whether coal-based DRI production will be economically feasible in the United States. No matter how spectacular DRI growth is over the next decade, it will not be able to replace more than a fraction of the world's blast furnace production because of technological restrictions. The blast furnace is expected to remain the mainstay of the iron and steel industries in most developed countries over the next 25 years.

Since 1983, five areas or countries (China, Europe, the Former Soviet Union (FSU), Japan, and North America) have accounted for more than 80% of the world's pig iron production. In three of these (Europe, Japan and North America) pig iron production has remained virtually constant. In recent years, production has fallen considerably in the FSU and risen dramatically in China. Production also has increased substantially in other parts of asia, particularly Asia, India, Korea, and Taiwan. Even including Japan, Asia's share of world pig iron production rose from 29.9% in 1983 to 43.5% in 1994. This trend is expected to continue.

The increase in consumption in Asia is expected to benefit Australia, primarily. Australia and Brazil are the two leading exporters of iron ore; each accounts for about 30% of the world total, while the next closest exporter accounts for less than 10% of the world total. Of the two, Australia appears to be better positioned to take advantage of growth of iron ore consumption in Asia because of Australia's proximity and the consequent lower freight rates.

There was a trend in the international market away from sintering of iron ore toward pelletization. This was driven, in large part, by environmental considerations.

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TABLE 1
SALIENT IRON ORE STATISTICS 1/

(Thousand metric tons and thousand dollars unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Iron ore (usable, 2/ less than 5% manganese):					
Production	56,400	56,800	55,600	55,700	58,400
Shipments	57,000	56,800	55,600	56,300	57,600
Value	$1,570,000 r/	$1,530,000 r/	$1,550,000 r/	$1,510,000 r/	$1,580,000
Average value at mines, dollars per ton	$27.52 r/	$26.91 r/	$27.81 r/	$26.87 r/	$27.44
Exports	3,200	4,050	5,060	5,060	4,980
Value	$124,000	$156,000	$187,000	$167,000	$163,000
Imports for consumption	18,100	13,300	12,500	14,100	17,500
Value	$560,000	$437,000	$396,000	$419,000 r/	$499,000
Consumption (iron ore and agglomerates)	76,900	66,400	75,100	76,800	76,900
Stocks, Dec. 31:					
At mines, plants and loading docks 3/	4,800	4,850	3,780	2,500	2,750
At receiving docks 4/	2,270	2,980	2,980	2,290	2,230
At consuming plants	15,900	17,600	16,100	16,500	16,300
Total 5/	23,000	25,400	22,900	21,300	21,300
World: Production	983,000 r/	956,000	949,000 r/	983,000 r/	995,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Direct-shipping ore, concentrates, agglomerates, and byproduct ore.

3/ Excludes byproduct ore.

4/ Transfer and/or receiving docks of Lower Lake ports.

5/ Sum of stocks at mines, consuming plants, and U.S. docks.

TABLE 2
EMPLOYMENT AT IRON ORE MINES AND BENEFICIATING PLANTS, QUANTITY AND TENOR OF ORE PRODUCED, AND AVERAGE OUTPUT PER WORKER-HOUR IN THE UNITED STATES IN 1994, BY DISTRICT AND STATE 1/

District and State	Average number of employees	Worker-hours (thousands)	Production (thousand metric tons)			Iron content, natural (percent)	Average per worker-hour (metric tons)		
			Crude ore	Usable ore	Iron contained (in usable ore)		Crude ore	Usable ore	Iron contained
Lake Superior:									
Michigan	2,050	4,180	43,300	13,900	8,620	62.1	10.35	3.32	2.06
Minnesota	5,020	10,500	148,000	44,000	27,800	63.3	14.01	4.18	2.64
Total or average	7,070	14,700	191,000	57,900	36,500	63.0	12.97	3.93	2.48
Other States 2/	137	258	553	480	296	61.6	2.14	1.86	1.14
Grand total or average	7,200	15,000	192,000	58,400	36,800	63.0	12.79	3.90	2.45

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes California, Missouri, New Mexico, South Dakota, Texas, and Utah.

TABLE 3
CRUDE IRON ORE 1/ MINED IN THE UNITED STATES IN 1994, BY DISTRICT, STATE, AND MINING METHOD 2/

(Thousand metric tons unless otherwise specified and exclusive of ore containing 5% or more manganese)

District and State	Number of mines	Open pit	Underground	Total quantity
Lake Superior:				
Michigan	2	43,300	–	43,300
Minnesota	9	148,000	–	148,000
Total	11	191,000	–	191,000
Other States:				
Missouri	1	–	545	545
Other 3/	7	183	–	183
Total	8	183	545	729
Grand total	19	191,000	545	192,000

1/ Excludes byproduct ore.

2/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes California, New Mexico, South Dakota, Texas, and Utah.

TABLE 4
USABLE IRON ORE PRODUCED IN THE UNITED STATES IN 1994, BY DISTRICT, STATE, AND TYPE OF PRODUCT 1/

(Thousand metric tons and exclusive of ore containing 5% or more manganese)

District and State	Direct shipping ore	Concentrates	Agglomerates 2/	Total quantity
Lake Superior:				
Michigan	114	–	13,800	13,900
Minnesota	231	34	43,800	44,000
Total	345	34	57,500	57,900
Other States:				
Missouri	–	232	13	245
Other 3/	235	–	–	235
Total	235	232	13	480
Grand total	580	265	57,500	58,400

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Data may include pellet chips and screenings.

3/ Includes California, New Mexico, South Dakota, Texas, and Utah.

TABLE 5
SHIPMENTS OF USABLE IRON ORE 1/ FROM MINES IN THE UNITED STATES IN 1994 2/

(Exclusive of ore containing 5% or more manganese)

District and State	Gross weight of ore shipped (Thousand metric tons)				Average iron content, natural (percent)	Value (thousands)
	Direct shipping ore	Concentrates	Agglomerates	Total		
Lake Superior:						
Michigan	–	172	13,600	13,800	62.1	W
Minnesota	323	28	43,000	43,300	63.3	$1,160,000
Total reportable or average	323	200	56,500	57,100	63.0	1,160,000
Other States:						
Missouri	–	304	12	316	70.9	W
Other 3/	237	–	–	237	51.9	4,520
Total reportable or average 3/	237	304	12	553	64.7	4,520
Total withheld	–	–	–	–	–	419,000
Grand total or average	560	503	56,600	57,600	63.0	1,580,000

W Withheld to avoid disclosing company proprietary data; included in "Total withheld."

1/ Includes byproduct ore.

2/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes California, New Mexico, South Dakota, Texas, and Utah.

TABLE 6
CONSUMPTION OF IRON ORE 1/ AT U.S. IRON AND STEEL PLANTS 2/

(Thousand metric tons)

Year	Iron ore originating areas					
	U.S. ores		Canadian ores			
	Great Lakes	Other U.S.	Great Lakes	Other Canada	Foreign ores	Total
1993	54,900	515	--	6,180	8,310	69,900
1994	56,100	163	888	6,510	7,820	71,500

1/ Excludes dust, mill scale, and other revert iron-bearing materials added to sinter.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: American Iron Ore Association.

TABLE 7
CONSUMPTION OF IRON ORE AND AGGLOMERATES AT U.S. IRON AND STEEL PLANTS, BY TYPE OF PRODUCT 1/

(Thousand metric tons)

Type of product	1993	1994
Blast furnaces:		
Direct-shipping ore	1,960	1,820
Pellets	60,700	61,100
Sinter 2/	12,500	12,100
Total	75,100	75,100
Steelmaking furnaces:		
Direct-shipping ore	11	20
Pellets	61	65
Sinter 2/	4	19
Total	76	104
Grand total	75,200	75,200

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes briquettes, nodules, and other.

Source: American Iron and Steel Institute.

TABLE 8
U.S. CONSUMPTION OF IRON ORE AND AGGLOMERATES, BY END USE 1/

(Thousand metric tons and exclusive of ore containing 5% ore more manganese)

Year	Blast furnaces	Steel furnaces	Sintering plants 2/	Miscella-neous 3/	Subtotal integrated iron and steel plants 4/	Direct-reduced iron for steelmaking 5/	Nonsteel end uses 6/	Total
1993	63,900	76	5,790	86	69,900	441	1,130	71,500
1994	65,500	80	5,770	103	71,500	716	958	73,200

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes dust, mill scale, and other revert iron-bearing materials.

3/ Sold to nonreporting companies or used for purposes not listed.

4/ Data from American Iron Ore Association.

5/ U.S. Bureau of Mines estimates based on production reports compiled by Midrex Corp.

6/ Includes iron ore consumed in production of cement and iron ore shipped for use in manufacturing paint, ferrites, heavy media, cattle feed, refractory and weighing materials, and for use in lead smelting. Data from U.S. Bureau of Mines surveys.

TABLE 9
U.S. EXPORTS OF IRON ORE AND AGGLOMERATES, BY COUNTRY OF DESTINATION 1/

(Thousand metric tons and thousand dollars)

Country	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Canada	5,040	165,000	4,970	162,000
India	(2/)	5	(2/)	5
Mexico	3	228	2	199
Venezuela	(2/)	8	(2/)	48
Other	15	1,170	2	86
Total	5,060	167,000	4,980	163,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
U.S. EXPORTS OF IRON ORE AND AGGLOMERATES, BY TYPE OF PRODUCT 1/

Type of product	1993 Quantity (thousand metric tons)	1993 Value (thousand dollars)	1993 Unit value 2/ (dollars per ton)	1994 Quantity (thousand metric tons)	1994 Value (thousand dollars)	1994 Unit value 2/ (dollars per ton)
Concentrates	8	300	37.50 r/	15	488	32.53
Coarse ores	1	53	53.00 r/	2	54	27.00
Fine ores	7	284	40.57 r/	67	1,000	14.99
Pellets	5,030	165,000	32.81	4,890	161,000	32.90
Briquettes	--	--	--	(3/)	13	43.55
Other agglomerates	13	1,090	84.00 r/	1	119	119.00
Roasted pyrites	1	99	99.00 r/	3	250	83.33
Total	5,060	167,000	32.98 4/	4,980	163,000	32.70 4/

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices; may not add to totals shown.

2/ Unit values shown are calculated from unrounded data.

3/ Less than 1/2 unit.

4/ Weighted average calculated from unrounded data by dividing total value by total tonnage.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS OF IRON ORE AND AGGLOMERATES, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Australia	254	3,550	675	4,760
Brazil	2,870	63,000	3,610	74,900
Canada	7,440	243,000	10,100	318,000
Chile	68	1,240	134	2,480
Mauritania	206	3,750	124	2,100
Norway	2	69	16	663
Peru	1	57	(2/)	6
Sweden	60	1,970	45	1,430
Venezuela	3,170 r/	102,000 r/	2,780	94,200
Other	3	144	11	338
Total	14,100	419,000 r/	17,500	499,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS OF IRON ORE AND AGGLOMERATES, BY TYPE OF PRODUCT 1/

Type of product	1993 Quantity (thousand metric tons)	1993 Value (thousand dollars)	1993 Unit value 2/ (dollars per ton)	1994 Quantity (thousand metric tons)	1994 Value (thousand dollars)	1994 Unit value 2/ (dollars per ton)
Concentrates	1,180	21,700	18.48	1,130	18,100	16.01
Coarse ores	134	3,740	27.90 r/	1,920	65,100	34.00
Fine ores	2,760	54,500	19.75	3,600	57,300	15.92
Pellets	9,790	333,000	34.00	9,880	331,000	33.46
Briquettes	--	--	--	114	8,310	72.90
Other agglomerates	213	6,260	29.40 r/	819	18,800	22.99
Roasted pyrites	3	150	50.00 r/	10	338	33.80
Total	14,100	419,000 r/	29.85 3/	17,500	499,000	28.54 3/

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices; may not add to totals shown.

2/ Unit values shown are calculated from unrounded data.

3/ Weighted average calculated from unrounded data by dividing total value by total tonnage.

Source: Bureau of the Census.

TABLE 13
U.S. IMPORTS OF IRON ORE AND AGGLOMERATES IN 1994, BY COUNTRY AND TYPE OF PRODUCT 1/

(Thousand metric tons)

Country of origin	Concentrates	Coarse ores	Fine ores	Pellets	Other agglomerates	Roasted pyrites	Total
Australia	--	--	675	--	--	--	675
Brazil	218	412	2,620	263	98	--	3,610
Canada	912	241	65	8,330	525	(2/)	10,100
Chile	--	--	--	--	134	--	134
Mauritania	--	--	124	--	--	--	124
Sweden	--	--	--	--	45	--	45
Venezuela	--	1,260	117	1,290	114	--	2,780
Other	--	--	--	--	16	10	26
Total	1,130	1,920	3,600	9,880	933	10	17,500

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 14
AVERAGE UNIT VALUE FOR SELECTED IMPORTS OF IRON ORE AND AGGLOMERATES IN 1994

Type of product	Country of origin	Average unit value 1/ (dollars per metric ton gross weight)
Coarse ores	Venezuela	34.76
Fine ores	Brazil	17.41
Do.	Mauritania	16.95
Do.	Venezuela	26.04
Pellets	Brazil	34.50
Do.	Canada	33.91
Do.	Venezuela	30.29

1/ Weighted averages of individual Customs values.

Source: Bureau of the Census.

TABLE 15
U.S. IMPORTS OF IRON ORE AND AGGLOMERATES, BY CUSTOMS DISTRICT 1/

(Thousand metric tons and thousand dollars)

	1993		1994	
Customs district	Quantity	Value	Quantity	Value
Baltimore	3,200	87,400	4,480	106,000
Charleston	581	18,000	289	8,970
Chicago	2,010	41,300	2,290	46,300
Cleveland	603	17,400	1,040	33,600
Detroit	465	17,400	1,890	73,000
Houston-Galveston	38	968	38	1,140
Mobile	2,590	94,500	3,170	104,000
New Orleans	1,350 r/	32,300 r/	1,820	44,700
Philadelphia	3,240	110,000	2,450	80,900
Other	8	202	5	150
Total	14,100	419,000 r/	17,500	499,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 16
U.S. IMPORTS OF PELLETS, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

	1993		1994	
Country	Quantity	Value	Quantity	Value
Brazil	442	14,200	263	9,090
Canada	6,380	221,000	8,330	283,000
Sweden	13	530	--	--
Venezuela	2,960	96,900	1,290	38,900
Total	9,790	333,000	9,880	331,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 17

IRON ORE, IRON ORE CONCENTRATES, AND IRON ORE AGGLOMERATES: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	Gross weight 4/					Metal content 5/				
	1990	1991	1992	1993	1994 e/	1990	1991	1992	1993	1994 e/
Albania e/ 6/	930 7/	750	200 7/	150	–	410	350	88	85	–
Algeria	2,940	2,340	2,560	2,000 r/ e/	2,350	1,470	1,170 e/	1,250 e/	1,000 r/ e/	1,150
Argentina	992	259	6 r/	3 r/	3	681	171	4 r/	2 r/	2
Australia	111,000	117,000	112,000 r/	121,000	128,000 7/	69,800	68,700	69,800 r/	74,800	80,900
Austria	2,310 r/	2,130 r/	1,630	1,440 r/	1,660 7/	653	481	515 r/	452 r/	520
Azerbaijan	XX	XX	400	300 e/	200	XX	XX	220	165 r/	110
Bolivia	125	102	55	51 r/	48	79	72	35	32 r/	30
Bosnia and Herzegovina e/	XX	XX	500	250	200	XX	XX	150	100	70
Brazil	152,000	152,000 r/	146,000 r/	159,000 r/	166,000 7/	99,900 e/	99,900 r/ e/	96,100 r/ e/	105,000 r/ e/	109,000
Bulgaria	1,080	800 e/	800 e/	850 r/ e/	800	321	182	239 r/	180 e/	180
Canada 8/	34,900	36,400	32,700	30,500 r/	36,600 7/	22,000	22,900	21,500	20,000 e/	23,000
Chile	7,900	8,690	7,640 r/	6,520 r/	6,400	5,040 e/	5,820	5,120 r/	4,390 r/	4,300
China e/	168,000	176,000	198,000	235,000	240,000	50,500	52,800	59,300 r/	70,400 r/	72,100
Colombia	628	450 r/	674	545 r/	610 7/	283 e/	265 r/ e/	300	245 r/ e/	275
Croatia	XX	XX	– r/	– r/	–	XX	XX	– r/	– r/	–
Czech Republic	XX	XX	XX	– r/	–	XX	XX	XX	– r/	–
Czechoslovakia 9/	1,830	1,740	1,410	XX	XX	540	526 e/	412	XX	XX
Egypt	2,410	2,140	2,400	2,190 r/	2,100	1,500 e/	1,300 e/	1,260	1,450 e/	1,450
France	8,730	7,470	5,710	3,520	2,550	2,790	2,320 e/	1,700	1,060 r/	765
Germany: Western states	83	120	109	146 r/	140	12	17	15	20 r/	20
Greece 6/	2,110	2,020	1,500 e/	1,420 e/	1,350	861	815	610 e/	575 e/	550
Guatemala	6	5	1	3 e/	3	3	3	1	2 e/	2
India	53,700 r/	56,900 r/	54,900 r/	55,800 r/	57,000	34,400 r/	36,400 r/	35,100 r/	35,700 r/	36,500
Indonesia	145	173	288	341	335	84	100	145	198 r/	194
Iran 10/	3,240	4,890	5,650	9,870	8,690 7/	1,800 e/	2,700 e/	3,000 e/	4,800 e/	4,300
Japan	34	31	40	11 r/	3	21	19	24	6	2
Kazakhstan e/	XX	XX	17,300	13,000 r/	10,500	XX	XX	9,500 r/ 7/	7,200 r/	5,800
Korea, North e/	10,000	10,000	10,500	10,500	11,000	4,700	4,700	4,900	4,900	4,900
Korea, Republic of	298	222	222	219 r/	191 7/	180	134	134	122 r/	115
Liberia	4,050	1,100	1,740	– e/	–	2,490 e/	710	1,000	– e/	–
Macedonia e/	XX	XX	20,000	20,000	20,000	XX	XX	1	1	1
Malaysia	344	376	320	223	203 7/	210	229	195	136	124
Mauritania	11,600	10,200	8,200	9,300	9,000	6,800 e/	6,500 e/	5,330 e/	5,900 r/ e/	5,400
Mexico 11/	15,000	13,000	15,000	15,000 e/	15,000	7,110	6,600	7,240	7,550	7,540 7/
Morocco	148	99	83	66 r/	64 7/	90	60	51	41 r/ e/	39
New Zealand 12/	2,300	2,270	2,930	2,390 r/	1,100	1,300 e/	1,300 e/	1,300 e/	1,300 e/	600
Nigeria e/	374 7/	398 7/	400	400	400	180	200	200	200	200
Norway	2,080	2,210	2,150	2,160 r/	2,460 7/	1,350	1,440	1,400	1,360	1,300
Peru	3,310	3,590	2,770 r/	5,090 r/	6,500	2,150	2,330	1,850 r/	3,400 r/	5,900
Poland	2	(13/)	–	– e/	–	1 e/	(13/) e/	–	– e/	–
Portugal 14/	14 r/	16 r/	15 r/	16 r/ e/	16	5 r/	6 r/	5 r/	6 r/	6
Romania	2,000	1,400 e/	1,250	904	951	275	199	180	130	152
Russia	XX	XX	82,100 r/	76,100 r/	73,300	XX	XX	45,000 e/	42,000 r/ e/	40,000
Serbia and Montenegro	XX	XX	551 r/	106 r/	32	XX	XX	176 r/	34 r/	10
Slovakia e/	XX	XX	XX	1,300	1,300	XX	XX	XX	350	350
South Africa, Republic of 15/	30,300	29,100 r/	28,200	29,400	32,300 7/	19,700	18,900 r/	18,300	19,100 e/	20,700 7/
Spain 16/	3,030 e/	3,890 r/	2,970 r/	2,480 r/	2,500	1,440	1,740 r/	1,330 r/	1,110 r/	1,100
Sweden	19,900	19,300	19,300	18,700	19,700 7/	12,900	11,100	9,790	9,800 e/	10,000
Thailand	129	240	427	209 r/	300	71	132	235	115 r/	165
Tunisia	291	295	291	299 r/	240 7/	154 e/	156 e/	151 e/	153 r/ e/	129 7/
Turkey	4,920	5,340	5,920	6,510 r/	7,050	2,690	2,900 e/	3,200 e/	3,550 r/ e/	3,840
Ukraine e/	XX	XX	75,700 7/	65,000 r/	51,300	XX	XX	42,000 r/	35,000 r/	28,000
U.S.S.R. 17/	236,000	199,000	XX	XX	XX	132,000 e/	110,000 e/	XX	XX	XX
United Kingdom	55	59	31 r/	1 r/	1	13 r/	13	7 r/	1 r/	1
United States	56,400	56,800 r/	55,600	55,700	58,400 7/	35,700	35,800 r/	35,300	35,200 r/	36,800 7/
Venezuela	20,100	21,200	18,100	16,900	16,100 7/	13,100	13,800	11,800	11,000 e/	10,500
Yugoslavia e/ 18/	4,130 7/	2,570	XX	XX	XX	1,580	900	XX	XX	XX
Zambia 19/	– r/	– r/	– r/	– r/	–	– r/	– r/	– r/	– r/	–
Zimbabwe	1,260	1,140	1,180	375 e/	4	730 e/	660 e/	710 e/	225 e/	2
Total	983,000 r/	956,000	949,000 r/	983,000 r/	995,000	540,000	518,000 r/	498,000 r/	510,000 r/	519,000

See footnotes at end of table.

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Table includes data available through July 24,1995.
3/ In addition to the countries listed, Cuba and Vietnam may also produce iron ore, but definitive information on output levels, if any, is not available.
4/ Insofar as availability of sources permits, gross weight data in this table represent the nonduplicative sum of marketable direct-shipping iron ores, iron ore concentrates, and iron ore agglomerates produced by each of the listed countries. Concentrates and agglomerates produced from imported iron ores have been excluded under the assumption that the ore from which such materials are produced has been credited as marketable ore in the country where it was mined.
5/ Data represent actual reported weight of contained metal or are calculated from reported metal content. Estimated figures are based on latest available iron content reported, except for the following countries for which grades are U.S. Bureau of Mines estimates: Albania, Azerbaijan, Kazakstan, North Korea, and Ukraine.
6/ Nickeliferous iron ore.
7/ Reported figure.
8/ Series represent gross weight and metal content of usable iron ore (including byproduct ore) actually produced, natural weight.
9/ Dissolved Dec. 31, 1992.
10/ Data are for year beginning Mar. 21 of that stated.
11/ Gross weight calculated from reported iron content based on grade of 66% Fe.
12/ Concentrates from titaniferous magnetite beach sands.
13/ Less than 1/2 unit.
14/ Includes manganiferous iron ore.
15/ Includes magnetite ore as follows, in thousand metric tons: 1990--5,560 (revised); 1991--5,660; 1992--4,650; 1993--4,340; and 1994--3,460.
16/ Includes byproduct ore.
17/ Dissolved in Dec. 1991.
18/ Dissolved in Apr. 1992.
19/ Entry discontinued in 1993. Magnetite used as a mineral processing media only.

TABLE 18
SELECTED PRICES FOR IRON ORE IN THE JAPANESE MARKET

(F.o.b. shipping port basis. U.S. cents per dry long ton of iron unless otherwise specified)

Country and producer	Ore type	(April 1 - March 31) Fiscal Year 1993 r/	Fiscal Year 1994
Australia:			
Hamersley Iron Pty. Ltd. and Mount Newman Mining Co. Pty. Ltd.	Lump ore	35.34	33.26
Do.	Fines	28.35	25.66
Robe River Iron Associates	do.	23.87	20.41
Savage River Mines Ltd.	Pellets	39.45	39.45
Brazil:			
Cia. Nipo-Brasileira de Pelotizacao (Nibrasco)	do.	41.68	41.68
Cia. Vale do Rio Doce (Carajas)	Fines	25.92	23.51
Do.	Lump ore	29.99	28.22
Cia. Vale do Rio Doce (Itabira)	do.	26.32	24.77
Do.	Fines	25.42	23.01
Mineracoes Brasileiras Reunidas S.A.	do.	25.75	24.23
Do.	do.	25.91	23.45
Samarco Mineracão S.A.	Pellet feed	21.35	19.33
Canada:			
Iron Ore Co. of Canada (Carol Lake)	Concentrates	24.65	22.31
Chile:			
Minera del Pacifico S.A. (El Algarrobo)	Pellets	38.85	38.85
Minera del Pacifico S.A. (El Romeral)	Fines	19.69	17.42
India:			
Minerals and Metals Trading Corp. (Bailadila)	Lump ore	34.08	32.07
Do.	Fines	27.23	24.64
Peru:			
Empresa Minera del Hierro del Peru S.A.	Pellets	(1/)	--
South Africa, Republic of: 2/			
South African Iron and Steel Industrial Corp. Ltd.	Lump ore	27.60	26.15
Do.	Fines	21.57	19.52

r/ Revised.

1/ No quotation published.

2/ Price per dry metric ton unit.

Source: Trust Fund Project on Iron Ore Information, Iron Ore 1994.

TABLE 19
IRON ORE: WORLD PELLETIZING CAPACITY, BY CONTINENT AND COUNTRY IN 1994

	Number			Rated Capacity (million metric tons, gross weight)
	Sites	Plants 1/	Units	
North America:				
Canada	5	6	13	26.4
Mexico	5	6	6	9.5
United States	10	18	50	66.5
Total	20	30	69	102.4
South America:				
Argentina	1	1	4	1.0
Brazil	3	8	8	25.0
Chile	1	1	1	4.2
Peru	1	2	2	4.2
Venezuela	1	1	2	10.0
Total	7	13	17	44.4
Europe:				
Belgium - Luxembourg 2/	1	1	1	0.8
Czech Republic	1	1	1	0.2
Netherlands 2/	1	1	1	3.8
Norway 3/	2	3	3	3.2
Sweden	3	3	4	10.8
Turkey	1	1	1	1.3
Former U.S.S.R. 4/	7	13	NA	80.0
Yugoslavia 5/	1	1	1	0.6
Total	17	24	NA	100.7
Africa:				
Liberia 6/	1	1	1	3.0
Morocco 7/	1	1	1	0.8
Nigeria 2/	1	1	1	1.4
South Africa, Republic of	1	1	1	0.6
Total	4	4	4	5.8
Asia:				
Bahrain 2/	1	1	1	4.0
China 4/	4	4	NA	4.5
India 8/	1	1	1	3.0
Iran	1	1	1	2.5
Japan 2/	1	2	2	4.4
Total	8	9	NA	18.4
Oceania: Australia 9/	2	2	6	4.0
World total	58	82	NA	275.7

NA Not available.

1/ Staged additions are treated at some mining complexes as if they were separate plants. Site data exclude plants that have had no production since 1982. Plants that produced after 1979, but have been continuously idle since 1982, are cited in the footnotes because they could be reactivated at some reasonable cost.

2/ Pellets produced from imported direct-shipping ores and/or concentrates.

3/ The older of the two plants operated by A/S Sydvaranger at Kirkenes has been idle since 1986. In addition, the 0.50 Mmt-per-year plant operated by Norsk Jernverk at Mo-i-Rana was shut down in Jan. 1987 for an indefinite period, leaving only one plant in Norway on-line.

4/ Based on incomplete information.

5/ The Skopje plant operated by Rudnici i Zelezara was recently idled.

6/ Excludes the No. 1 pelletizing plant (capacity of 2.4 Mmt/yr) of the Bong Mining Co. The No. 1 plant has been idle since 1980.

7/ The Nador plant operated by Société d'Exploitation des Mines du Rif (SEFERIF) has been idle for several years.

8/ There is an additional plant with a capacity of 1.8 Mmt/yr at Mandovi in Goa, but it has been closed since 1982. The owner was planning to reopen the facility using high-grade blue dust from the Bellary Hospet area of Karnataka as feed.

9/ There is an additional plant with a capacity of 3.0 Mmt/yr at Dampier in Western Australia, but it has been closed since 1980.

Sources: Association of Iron Ore Exporting Countries (Geneva, Switzerland), Commodities Research Unit Ltd. (London, United Kingdom), International Iron and Steel Institute (Brussels, Belgium), Metal Bulletin Books Ltd. (Surrey, United Kingdom), United Nations Commission on Trade and Development (UNCTAD), UNCTAD Trust Fund Project on Iron Ore Information, and U.S. Bureau of Mines.

IRON OXIDE PIGMENTS

By Michael J. Potter

Iron oxide pigments (IOP) are said to be the largest-volume colored inorganic pigments used. They are nontoxic, relatively low cost, and have a wide range of applications. Natural iron oxides generally cost less than synthetic iron oxides; often, the two types are blended to make use of the advantages of each. The largest end-use areas for IOP in 1994 continued to be the construction and coatings industries. The former includes concrete, cement, mortars, paving, bricks, blocks, and roof tiles. The term coatings covers a wide range of paints, powder coatings, industrial finishes, lacquers, and varnishes. A journal article described IOP, including producing countries and companies; markets and end-uses such as construction, coatings, plastics, etc.; and micaceous iron oxides.[1]

Production

U.S. sales of crude IOP in 1994 were 46,400 metric tons (mt), according to the U.S. Bureau of Mines (USBM). Sales of finished natural IOP, 63,000 mt, were 13% higher than in 1993. The tonnage of finished synthetic IOP sold in 1994 was about the same as in 1993. (The quantity of 75,800 mt shown in table 2 is believed to contain a few thousand mt of low-value material which was inadvertently included.)

Sold-or-used data for crude IOP were developed by the USBM by means of a voluntary survey. Data were obtained from all six known companies, representing a 100% response rate. In a second voluntary survey, data were received by the close-out date for 12 of the 17 known operations, or 71%, which produced finished IOP. The 12 respondents reported a production of about 104,000 mt, or 75% of the finished pigments sold shown in tables 1 and 2. Estimates for the remaining five operations were derived from last year's production levels and trends.

World Review

A naturally occurring micaceous iron oxide (MIO), known as Ironor P, was being mined in Morocco and processed in northern France. Suitable processing of the crude ore produces a pigment consisting of lamellar particles which have a metallic sheen that resembles mica; thus the term "micaceous." The British railway system has been a traditional user of MIO coatings.[2]

In northeastern England, a synthetic MIO pigment was being produced using scrap iron as the primary raw material. In this process, lamellar crystals of very pure iron oxide are formed. Bridges, towers, and other steel structures, large and small, in Britain and Europe have been painted with a protective system incorporating synthetic MIO.[3]

Outlook

Through product development, granular pigments produced by spray drying have recently been introduced to the construction industry. Compared with pigments in powder form, granular pigments are free flowing and almost dust free. This is said to make handling, storage, and metering simpler and cheaper. Liquid formulations, or slurries, also have been developed for ease of handling, along with chemical additives to improve overall pigment performance.[4]

For natural iron oxides, recent emphasis has included quality improvement, strong customer service, and technical assistance. Value-added pigments to be considered for future production and distribution may include surface coating of pigment particles for plastics and paints, calcination, preblended mixes, etc.[5]

IOP are partly replacing heavy metal-based pigments in certain applications as the manufacture and use of the latter have come under increasing legislative and regulatory control. IOP also can be used in aqueous systems, an advantage because of the current concern over volatile organic component (VOC) levels in paints and other coatings and the move toward water-based systems.

The Asia-Pacific region is thought to offer good potential for growth and product expansion over the next 5 to 10 years. In China, the automotive industry has been experiencing rapid expansion, and joint ventures between Western and Chinese coatings manufacturers have emerged. Vietnam, Indonesia, and Malaysia appear to have growth potential in paint and coatings consumption. South America, especially Brazil, is thought to be another promising region for automotive coatings and wood finishing products.[6]

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[1] Kendall,T. Inorganic Coloured Pigments. Ind. Miner. (London), No. 317, Feb. 1994, pp.49-59.

[2] Duchan, J.C. Natural Micaceous Iron Oxide Yields Performance. Paint & Coatings Industry, v. 10, No. 10, p. 30.

[3] Carter, E. Synthetic Micaceous Iron Oxide for Anticorrosion Coatings. American Paint & Coatings Journal, v. 78, No. 32, Jan. 31, 1994, pp. 43,46.

[4] P. 56 of work cited in footnote 1.

[5] Mauney, S.S. Natural Iron Oxide Pigments-Rebirth Through Innovation. Mining Engineering, v. 46, No. 1, Jan. 1994, p. 73.

[6] Pp. 53 and 56 of work cited in footnote 1.

TABLE 1
SALIENT U.S. IRON OXIDE PIGMENTS STATISTICS 1/

(Metric tons, unless otherwise noted)

		1990	1991	1992	1993	1994
Mine production		32,400	34,100	37,300	36,200	W
Crude pigments sold or used		37,100	40,200	39,300	35,800	46,400
Value	thousands	$4,620	$4,480	$4,670	$5,020	$6,010
Finished pigments sold		125,000	117,000	121,000	126,000	139,000
Value	thousands	$139,000	$133,000	$136,000	$140,000	$143,000
Exports		9,540	20,600	21,100	22,400	21,300
Value	thousands	$18,700	$33,800	$32,200	$32,000	$30,700
Imports for consumption		34,100	34,700	45,100	43,600	51,400
Value	thousands	$37,300	$39,400	$49,900	$57,300	$61,400

W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

TABLE 2
FINISHED IRON OXIDE PIGMENTS SOLD BY PROCESSORS IN THE UNITED STATES, BY KIND 1/

Kind	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Natural				
Black: Magnetite	W	W	W	W
Brown: Iron oxide	W	W	W	W
Umbers:				
Burnt	W	W	W	W
Raw	W	W	W	W
Red:				
Iron oxide 2/	28,300	$5,400	30,300	$5,840
Sienna, burnt	W	W	W	W
Yellow:				
Ocher	W	W	W	W
Sienna, raw	W	W	W	W
Undistributed	27,500 r/	11,700 r/	32,600	13,200
Total	55,800 r/	17,100 r/	63,000	19,100
Synthetic				
Black: Iron oxide	17,500	27,800	16,600	26,800
Brown: Iron oxide 3/	6,960	13,200	6,670	12,900
Red: Iron oxide	W	W	W	W
Yellow: Iron oxide	W	W	W	W
Mixtures of natural and synthetic:				
Iron oxides	(4/)	(4/)	(4/)	(4/)
Other: Specialty oxides	(4/)	(4/)	(4/)	(4/)
Undistributed	45,400	81,800	52,500	84,200
Total	69,800	123,000	75,800	124,000
Grand total	126,000	140,000	139,000	143,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Undistributed."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes pyrite cinder.

3/ Includes "Other: Specialty oxides," and "Mixtures of natural and synthetic: Iron oxides."

4/ Included with "Synthetic: Brown Iron oxide" to avoid disclosing company proprietary data.

TABLE 3
PRODUCERS OF IRON OXIDE PIGMENTS, REGENERATOR IRON OXIDES, AND STEEL-PLANT WASTE IRON OXIDES IN THE UNITED STATES IN 1994

Producers	Plant Location
Finished pigments:	
American Minerals, Inc.	Camden, NJ
Blue Ridge Talc Co., Inc.	Henry, VA
Columbian Chemicals Co.	St. Louis, MO
DCS Color & Supply Co., Inc.	Milwaukee, WI
Harcros Pigments Inc.	Emeryville, CA; East St. Louis, IL; Easton, PA
Hilton-Davis Co.	Newark, NJ
Hoover Color Corp.	Hiwassee, VA
Miles Inc., Industrial Chemicals Div.	New Martinsville, WV
Mineral Pigments Corp.	Beltsville, MD
New Riverside Ochre Co., Inc.	Cartersville, GA
Pea Ridge Iron Ore Co.	Sullivan, MO
Prince Manufacturing Co.	Quincy, IL and Bowmanstown, PA
Solomon Grind-Chem Services Inc.	Springfield, IL
Swansea Minerals Inc.	Tempe, AZ
Crude pigments:	
Cleveland-Cliffs Iron Co., Mather Mine and Pioneer plant (closed July 31, 1979; shipping from stockpile.)	Negaunee, MI
Hoover Color Corp.	Hiwassee, VA
New Riverside Ochre Co., Inc.	Cartersville, GA
Pea Ridge Iron Ore Co.	Sullivan, MO
Swansea Minerals Inc.	Tempe, AZ
Virginia Earth Pigments Co.	Hillsville, VA
Regenerator and steel plant waste iron oxides:	
Armco Inc.	Ashland, KY
Shance Chemical Corp.	Philadelphia, PA
Weirton Steel Corp.	Weirton, WV

TABLE 4
ESTIMATED IRON OXIDE PIGMENT CONSUMPTION, BY END USE, AS A PERCENTAGE OF REPORTED SHIPMENTS

End use	All iron oxides		Natural iron oxides		Synthetic iron oxides	
	1993	1994	1993	1994	1993	1994
Coatings (industrial finishes, trade sales: lacquers, paints, varnishes)	19	19	15	14	22	23
Construction materials (cement, mortar, preformed concrete, roofing granules)	34	32	W	W	W	W
Colorants for ceramics, glass, paper, plastics, rubber, textiles	13	12	12	12	14	12
Foundry sands	8	8	17	17	--	--
Industrial chemicals (such as catalysts)	6	5	2	W	10	W
Ferrites	W	W	W	W	W	W
Animal feed and fertilizers	W	W	W	W	W	2
Other (also including cosmetics, magnetic ink and toner, and polishing agents)	20 1/	24 1/	54 2/	57 3/	54 2/	63 4/
Total	100	100	100	100	100	100

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Includes ferrites and animal feed and fertilizers iron oxide usage.

2/ Includes construction materials, ferrites, and animal feed and fertilizers iron oxide usage.

3/ Includes construction materials, industrial chemicals, ferrites, and animal feed and fertilizers iron oxide usage.

4/ Includes construction materials, industrial chemicals, and ferrites iron oxide usage.

TABLE 5
U.S. EXPORTS OF IRON OXIDES AND HYDROXIDES, BY COUNTRY 1/

Country	1993				1994			
	Pigment grade		Other grade		Pigment grade		Other grade	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	3	$11	121	$377	3	$10	513	$284
Australia	2,090	2,830	1,450	2,400	1,570	1,940	1,290	2,250
Austria	--	--	929	2,010	--	--	39,200	3,430
Belgium	4	33	304	684	13	73	1,330	2,680
Brazil	49	345	1,100	2,290	147	868	1,060	1,730
Canada	174	149	87,700	19,400	213	247	104,000	24,000
Ecuador	31	13	2,140	172	--	--	1,330	208
Germany	1,870	1,310	2,320	4,590	543	820	1,330	4,040
Hong Kong	1,100	2,520	611	559	1,240	3,060	881	448
Indonesia	1,220	1,940	195	327	1,080	1,730	80	118
Italy	45	81	1,550	1,110	19	23	638	431
Japan	3,330	4,410	8,820	16,200	4,380	4,440	5,660	18,900
Korea, Republic of	2,690	7,090	2,910	10,900	3,130	8,610	1,290	4,660
Malaysia	608	749	165	316	1,000	721	215	238
Mexico	3,150	755	12,900	6,410	3,640	1,060	8,790	6,830
Netherlands	272	676	1,000	1,570	324	677	17,400	2,610
Singapore	96	227	1,980	4,730	129	21	2,490	3,320
South Africa, Republic of	1,050	1,510	81	123	915	1,270	214	384
Spain	--	--	84	222	--	--	24,900	451
Taiwan	677	704	1,580	2,970	231	265	2,190	1,910
Thailand	1,110	1,680	430	700	943	1,350	279	642
Trinidad and Tobago	--	--	839	51	20	4	733	77
United Kingdom	924	1,940	2,980	4,850	890	1,740	6,720	6,580
Venezuela	107	75	1,220	1,740	14	21	2,000	1,160
Other	1,790 r/	2,990 r/	6,100 r/	7,870 r/	862	1,740	3,900	7,400
Total	22,400	32,000	139,000	92,500	21,300	30,700	229,000	94,800

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF SELECTED IRON OXIDE PIGMENTS, BY TYPE 1/

Type	1993		1994		Sources, 1994 (metric tons)
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	
Natural:					
Earth colors 2/	300	$184	185	$185	France 159; United Kingdom 18; Germany 8; Russia 1; Japan (3/).
Micaceous	100	208	2,660	796	France 2,150; Canada 360; Austria 77; Netherlands 20; Germany 19; Australia 17; Spain 16; Japan 1; United Kingdom 1.
Umber	4,380	931	3,500	1,080	Cyprus 3,430; Germany 49; United Kingdom 20; Poland (3/); Russia (3/).
Vandyke brown	58	52	76	73	Germany 76.
Total	4,840	1,380	6,420	2,140	
Synthetic:					
Black	6,750	25,100	9,190	26,100	Japan 4,700; Germany 1,330; Sweden 1,070; China 1,040; India 399; Italy 233; Mexico 91; Canada 82; Hong Kong 63; United Kingdom 59; Austria 19; Brazil 15; Netherlands 14; Australia 1, Ireland 1.
Red	16,900	11,900	16,400	10,900	China 7,430; Canada 4,700; Germany 1,540; Spain 590; Japan 439; Mexico 399; United Kingdom 351; Hong Kong 311; Brazil 260; Italy 135; Sweden 120; Belgium 50; Netherlands 22; Colombia 7; Australia 1; Ireland 1; Switzerland (3/).
Yellow	11,900	12,500	15,800	16,200	Germany 6,020; China 4,800; United Kingdom 2,760; Italy 638; Brazil 595; Mexico 396; Spain 280; Belgium 107; France 57; India 42; Hungary 34; Hong Kong 33; Japan 4; Switzerland 2; Niger 1.
Other 4/	3,250	6,500	3,690	6,010	Germany 1,670; Canada 1,180; Japan 482; China 193; United Kingdom 66; Italy 46; Netherlands 19; Belgium 18; Mexico 9; Australia 4.
Total	38,800	55,900	45,000	59,300	
Grand total	43,600	57,300	51,400	61,400	

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes those earth colors not elsewhere specified or included.

3/ Less than 1/2 unit.

4/ Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF IRON OXIDE AND IRON HYDROXIDE PIGMENTS, BY COUNTRY 1/

Country	Natural				Synthetic			
	1993		1994		1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	(2/)	$5	17	$25	19	$17	6	$11
Austria	8	10	77	63	76	71	19	18
Belgium	--	--	--	--	63	97	175	560
Brazil	--	--	--	--	878	829	870	831
Canada	16	2	360	29	5,030	1,450	5,970	1,280
China	--	--	--	--	10,800	6,390	13,500	7,840
Cyprus	4,210	791	3,430	996	--	--	--	--
France	255	199	2,310	685	190	349	57	123
Germany	163	223	152	197	11,700	18,200	10,600	16,300
Hong Kong	--	--	--	--	536	376	407	290
Hungary	1	6	--	--	196	310	34	52
India	--	--	--	--	47	13	441	212
Italy	1	5	--	--	588	686	1,050	1,130
Japan	2	45	1	9	4,330	23,700	5,690	26,000
Mexico	103	13	--	--	959	959	895	820
Netherlands	7	10	20	8	346	499	55	75
Russia	--	--	1	32	--	--	--	--
Spain	--	--	16	8	425	193	871	594
Sweden	--	--	--	--	840	199	1,190	335
United Kingdom	77	60	39	60	1,700	1,550	3,240	2,720
Other	(2/)	7	(2/)	26	53	37	12	97
Total	4,840	1,380	6,420	2,140	38,800	55,900	45,000	59,300

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 8
NATURAL IRON OXIDE PIGMENTS: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(METRIC TONS)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina (ocher)	36 r/	77 r/	40 r/	28 r/	35
Austria	9,940	10,200	9,480	8,400 r/	8,000
Bosnia and Herzegovina e/	XX	XX	200	--	--
Brazil e/	5,500	5,500	5,500	5,500	5,500
Chile	15,600	6,760	22,900	7,110 r/	8,000
Cyprus (umber)	7,700	5,800	5,000	6,000 r/	9,000 4/
France e/	15,000	14,000	12,000	1,000 r/	1,000
Germany 5/	6,220 r/	7,040	10,100	7,710 r/	8,000
India (ocher)	126,000	156,000	160,000 e/	175,000 e/	175,000
Iran	3,720	3,750	2,310	2,500 e/	2,500
Italy e/	850	800	700	700	600
Pakistan (ocher)	1,380	1,890	5,130	6,200 r/	6,000
Paraguay (ocher) e/	330	330	330	330	330
South Africa, Republic of	2,910	1,120	1,110	1,190 r/	1,200
Spain: e/					
Ocher	8,990 4/	8,600	8,200	8,000	7,000
Red iron oxide	20,000	20,000	18,000	16,000	15,000
United States	32,400	34,100	37,300	36,200 r/	W
Yugoslavia 6/	1,210	800	XX	XX	XX
Zimbabwe	416	400 e/	538	550 e/	550

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

1/ Previously published and 1994 data are rounded by U.S. Bureau of Mines to three significant digits.

2/ Table includes data available through June 9, 1995.

3/ In addition to the countries listed, a considerable number of others undoubtedly produce iron oxide pigments, but output is not reported and no basis is available for formulating estimates of output levels. Such countries include, but are not limited to, Azerbaijan, China, Kazakhstan, Russia and Ukraine. Because unreported output is probably substantial, this table is not summed to provide a world total.

4/ Reported figure.

5/ Includes Vandyke brown.

6/ Dissolved in Apr. 1992. All production in Yugoslavia from 1990-91 came from Bosnia and Herzegovina.

KYANITE

By Michael J. Potter

Kyanite, when heated at high temperatures, is converted to mullite. Mullite in refractories and ceramic bodies will increase the fired strength, resistance to deformation under load, thermal resistivity, etc. Also, kyanite expands when calcined and this can offset shrinkage of other ingredients and produce a stable refractory body.[1]

Production

Kyanite was mined at two open-pit locations by Kyanite Mining Corp. in Buckingham County, VA. The company also operated benefication plants and calcining facilities for conversion of kyanite to mullite. High-temperature sintered mullite was produced by C-E Minerals at Americus, GA, and North American Refractories Co. at Greenup, KY. Electric-furnace-fused mullite was produced by Washington Mills Electro Minerals Corp. at Niagara Falls, NY. Data obtained from the kyanite and synthetic mullite producers are not publishable because of company proprietary data.

Consumption

The U.S. Bureau of Mines does not collect data on end uses of kyanite and synthetic mullite. However, refractories were a major end use, including cements/mortars, ramming mixes, and castables. With clay or other ingredients, kyanite is also used in firebrick, insulating brick, and kiln furniture. Finely ground kyanite, in the 200-mesh range, is used in body mixes for sanitary porcelain, wall tile, casting molds, special purpose ceramics, etc.[2]

Foreign Trade

Shipments of U.S. kyanite, mullite, and synthetic mullite were believed to have been made to foreign destinations, including Asia and Europe. Imports of andalusite in recent years have been largely from the Republic of South Africa.

World Review

Capacity.—Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgement of the author, can be brought into production within a short period of time with minimum capital expenditure.

The data in table 3 are estimated rated capacity for marketable product as of December 31, 1994. Actual capacity data were generally not available. For most countries, recent peak production or estimated production was considered to be equal to rated capacity.

Outlook

The iron and steel industry is a major user of refractories in general. Other users are the nonferrous metals, glass, cement, petroleum, and other industries. Advances in steelmaking and other process technology will require new and/or improved refractories because of more severe thermal and/or chemical exposure. There has been an increase in monolithic refractories, i.e., castables, plastics, and gunning mixes, which do not require firing for manufacture. Monolithics now comprise about 50% of the refractories market and are expected to continue to increase.[3]

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[1] Sweet, P. C. Kyanite and Related Minerals. Ch. in Industrial Minerals and Rocks. AIME, 6th ed., 1994, p. 926.

[2] Work cited in footnote 1.

[3] Semler, C. E. Overview of the U.S. Refractories Industry. Ceramic Industry, v. 143, No. 2, Feb. 1994, pp. 33, 35, and 36.

TABLE 1
PRICE OF KYANITE AND RELATED MATERIALS
(Dollars per metric ton)

	1994
Andalusite, transvaal, 57.5% Al_2O_3, 2,000 metric ton bulk, f.o.b.	160 -180
Andalusite, transvaal, 59.5% Al_2O_3, 2,000 metric ton bulk, f.o.b.	180 -200
Kyanite, USA, 54% to 60% Al_2O_3, 35-325 Tyler mesh, 18 ton lots, f.o.b. plant	
Raw	110 -140
Calcined	202 -232
Sillimanite, South African, 70% Al_2O_3, bags, c.i.f. main European port	285

Source: Industrial Minerals (London). Dec. 1994, No. 327, p. 63.

TABLE 2
U.S. IMPORTS 1/ FOR CONSUMPTION OF ANDALUSITE

Year	Quantity (metric tons)	Value2/ (thousands)
1993	12,200	$2,130
1994	7,900 e/	1,290 e/

e/ Estimated.

1/ Most material is from the Republic of South Africa.

2/ Customs value.

Source: Bureau of the Census.

TABLE 3
WORLD KYANITE AND RELATED MINERALS CAPACITY
DECEMBER 31, 1994

(Thousand metric tons)

	Capacity
North America:	
United States:	
Kyanite	W
Synthetic mullite	W
Total	W
South America:	
Brazil: Kyanite	1 e/
Europe:	
France: Andalusite	60
Germany: Synthetic mullite	15 e/
Spain: Andalusite	5
United Kingdom: Synthetic mullite	10
Other countries	120 e/
Total	210 e/
Africa:	
South Africa, Republic of:	
Andalusite	300 e/
Sillimanite	1 e/
Zimbabwe: Kyanite	2
Total	303 e/
Asia:	
China: Unspecified	3
India:	
Kyanite	30
Sillimanite	15
Total	45
Japan: Synthetic mullite	40 e/
Total	88 e/
Oceania:	
Australia:	
Kyanite	1 e/
Sillimanite	1 e/
Total	2 e/
World total 1/ 2/	600 e/

e/ Estimated. W Withheld to avoid disclosing company proprietary data.

1/ Excludes U.S. kyanite and synthetic mullite.

2/ Data do not add to total shown because of independent rounding.

TABLE 4
KYANITE: WORLD PRODUCTION, BY COUNTRIES 1/ 2/

(Metric tons)

Country 3/ and commodity	1990	1991	1992	1993	1994 e/
Australia:					
Kyanite e/	750	800	800	800	800
Sillimanite e/ 4/	100	100	100	100	100
Brazil: Kyanite e/	600	600	600	600	600
China: Unspecified e/	2,500	2,500	2,500	2,500	2,500
France: Andalusite e/	50,000	50,000	50,000	50,000	50,000
India:					
Kyanite	38,900	30,000	10,100 r/	11,400 r/	12,000
Sillimanite	18,200	11,600	18,800 r/	14,900 r/	15,000
Kenya: Kyanite e/	(5/)	(5/)	(5/)	(5/)	(5/)
Korea, Republic of:					
Andalusite	--	14	38	30 r/	30
South Africa, Republic of:					
Andalusite	284,000	210,000	230,000	188,000 r/	190,000
Sillimanite	256	422	632	569 r/	500
Spain: Andalusite e/	3,600	3,600	3,600	3,000	3,500
Sweden: Kyanite e/	(6/)	(6/)	(6/)	(6/)	(6/)
United States:					
Kyanite	W	W	W	W	W
Mullite, synthetic	W	W	W	W	W
Zimbabwe: Kyanite	160	2,460 r/	1,990	1,000	1,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 figures are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Owing to incomplete reporting, this table has not been totaled. Table includes data available through Mar. 28, 1995.

3/ In addition to the countries listed, a number of other nations produce kyanite and related materials, but output is not reported quantitatively, and no reliable basis is available for estimation of output levels.

4/ In addition, about 7,000 metric tons of sillimanite clay (also called kaolinized sillimanite) is produced annually containing 40% to 48% Al203.

5/ Less than 1/2 unit.

6/ Revised to zero.

LEAD

By Gerald R. Smith

Domestic lead mine production increased by about 2% in 1994, following a 3-year decline. Missouri remained the dominant producing State with an 80% share, and Alaska, Idaho, and Montana contributed an additional 19%. Lead was produced at 16 mines, employing approximately 1,300 people. The value of domestic mine production was approximately $300 million. Primary lead was processed at two smelter-refineries in Missouri, a smelter in Montana, and a refinery in Nebraska.

Several proposed rules were issued by Government agencies during 1994, affecting the regulation of new and existing uses, and clean-up activities for lead, as well as the disclosure of information regarding its potential risks. A final rule also was issued on contaminant level goals and regulations for drinking water. In addition, two reports were completed in compliance with mandates within the Housing and Community Development, and Residential Lead-Based Paint Hazard Reduction Acts of 1992, that concluded the need for additional protection from lead risk for children in tenant-based housing, and the need for standards to ensure availability of lead-based paint hazard insurance for property owners and for contractors involved in lead abatement activities.

Lead was consumed in about 200 plants in the manufacture of end-use products, including batteries, ammunition, covering for power and communication cable, building construction materials, and solders for motor vehicles, metal containers, and electrical and electronic components and accessories.

Lead-acid batteries continued to be the overwhelmingly dominant use of lead, accounting for about 84% of reported lead consumption in 1994. The Battery Council International reported a 1994 starting-lighting-ignition (SLI) battery production of 97.5 million units. This total included both original equipment and replacement automotive-type batteries. An estimated 1.031 million metric tons (Mmt) of lead were consumed in SLI batteries in 1994.

Monthly sales of lead from the National Defense Stockpile (NDS) were continued during 1994. Sales totaled about 63,400 metric tons (mt) (69,900 short tons) (st) leaving about 447,000 mt (493,000 st) in the NDS at yearend.

London Metal Exchange (LME) and North American producer average prices in December 1994 were $0.078 per pound and $0.079 per pound, respectively, above those in the final month of 1993. Prices rose steadily throughout the year with the yearly average LME and North American producer prices up by $0.064 and $0.054 per pound, respectively, compared with those of 1993.

Lead was mined in 48 countries, of which the top five accounted for 58% of the world total of 2.81 million tons. Australia was the largest producer, with 19% of the world total, followed by the United States (13%), China (12%), Peru (8%), and Canada (6%).

Legislation and Government Programs

Monthly sales of lead from the NDS were continued during 1994 and totaled about 63,400 mt (69,900 st). A revision in April 1994 to the Defense National Stockpile Center's (DNSC) Annual Materials Plan (AMP) for fiscal year 1994 (October 1, 1993, to September 30, 1994) increased the maximum disposal authority for lead in the fiscal year from 31,751 mt (35,000 st) to 68,039 mt (75,000 st). Actual sales totaled 67,143 mt (74,013 st), of which 52,322 mt (57,675 st) were made in the first 9 months of calendar year 1994. For fiscal year 1995, the DNSC proposed the sale of 31,751 mt (35,000 st) of lead. Actual sales of lead in the first 3 months of the fiscal year amounted to 11,064 mt (12,196 st), leaving about 447,000 mt (493,000 st) of lead in the NDS at yearend 1994. A proposal made by DNSC in November 1994 to sell an additional 22,680 mt (25,000 st) of lead on a long-term basis remained under discussion at yearend.

The Environmental Protection Agency (EPA), issued a proposed rule in March 1994, that would effectively ban the use of certain lead and zinc fishing sinkers. The proposed rule would impose a ban on all manufacture, import, and processing of fishing sinkers containing lead or zinc and which are 1 inch or less in any dimension for use in the United States 1 year after promulgation of the final rule. The distribution in commerce of such fishing sinkers would be prohibited 2 years after promulgation of the final rule. The rule would not prohibit the manufacture and processing of these sinkers solely for export, but their manufacturers and processors would be required to maintain records regarding the production, inventory, and shipment of these sinkers. After soliciting public comments in an initial 60-day comment period and a 60-day extension of the period, EPA continued to receive numerous comments from the public. In order to give all interested persons the opportunity to respond fully, the written comment period was extended to November 9, 1994.

In February, the Food and Drug Administration (FDA) announced its intentions to take several related actions to reduce the amount of lead in food attributable to the use of food and color additives and food ingredients whose use is generally recognized as safe (GRAS). The FDA identified the lead levels that it intended to propose as new, lower lead specifications for the most heavily used food and color additives and GRAS ingredients. Public comments on the feasibility of these specifications were accepted by the FDA through August 3, 1994.

The U.S. Senate, by a vote of 97 to 1, passed a bill entitled the Lead Exposure Reduction Act of 1994 at the end of May. This legislation had undergone significant changes since it was first introduced in 1992. The 1994 version contained restrictions on continuing use of certain lead-containing products in categories that included paints, pesticides, and packaging materials. It would further require the creation of an inventory by the EPA Administrator of uses of lead-containing products in commerce. From this inventory, a list was to be formulated of those lead-containing products that may present an unreasonable risk of injury to human health or the environment, and provision was to be made for the appropriate labeling of products included on this exposure concern list. In addition, the act would require any person commencing to manufacture, process, or import lead products for new applications in commerce to inform the Administrator of EPA of such activity. The U.S. House of Representatives did not reintroduce its version of this legislation during 1994.

EPA issued its final rule,effective June 30, 1994, on Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper. The final rule was amended to clarify language, and to restore special primacy requirements inadvertently deleted from the Code of Federal Regulations. The rule was promulgated on June 7, 1991, with two subsequent technical amendments issued in July 1991 and June 1992.

In May, the U.S. General Accounting Office (GAO) issued a report, entitled "Lead-Based Paint Poisoning--Children in Section 8 Tenant-Based Housing Are Not Adequately Protected," to the U.S. Senate and House of Representatives Committees on Banking, Housing, and Urban Affairs. The report was prepared in response to a requirement in the Housing and Community Development Act of 1992 that GAO review the enforcement of and compliance with federal lead safety laws and regulations as they apply to Section 8 Tenant-Based Housing. Section 8 federal assistance is provided to the tenant rather than to the housing project or to a public housing authority, as with public housing.

In another report issued by GAO to the U.S. Senate and House of Representatives Committees on Banking, Housing, and Urban Affairs, the need for abatement standards relating to lead-based paint hazards was emphasized. The report entitled, "Lead-Based Paint Hazards--Abatement Standards Are Needed to Ensure Availability of Insurance," was prepared in response to the mandates included in the Residential Lead-Based Paint Hazard Reduction Act of 1992. The act required EPA to develop work-practice standards for inspection and abatement activities, as well as health-based standards for lead-based paint hazards and lead-contaminated dust and soil. The act also required the Department of Housing and Urban Development (HUD) to issue guidelines primarily for reducing lead hazards in the agency's federally assisted properties. As an additional part of the mandate, the 1992 Act required that GAO address the problems that property owners face in obtaining insurance for lead-based paint hazards. This GAO report examined the risks facing property owners because of the limited availability of insurance for lead hazards and the reasons that insurance companies were excluding this coverage; the contractors' experiences in obtaining liability insurance for their lead abatement activities; and the measures taken by the States and the Federal Government for increasing the availability of liability insurance for lead-based paint hazards.

EPA issued two additional proposed rules concerning lead in September. The first, "Requirements for Lead-Based Paint Activities" governed lead-based paint activities, including risk assessment, identification, inspection, abatement, deleading, and demolition. The proposed regulation would ensure that individuals engaged in such activities are properly trained; that training programs are accredited; and that contractors engaged in such activities are certified. It would also establish standards for performing lead-based paint activities and require that all these activities be performed by certified individuals. EPA issued this proposed rule under the authority of the Toxic Substances Control Act directing EPA to promulgate such regulations. Written comments in response to this proposed rule were to be received by EPA by November 1, 1994. The second, "Significant New Uses of Lead," explored the possibility of issuing new regulations for certain uses of elemental lead and lead compounds under the Toxic Substances Control Act. The significant new uses rules would require individuals to notify EPA at least 90 days before commencing the manufacture, import, or processing of lead or lead compounds for uses identified by EPA as significant new uses. This rule was proposed by EPA to: (1) communicate its intention to regulate significant new uses of elemental lead and lead compounds; (2) identify components of its proposed regulatory approach; (3) request comment on issues related to this approach; and (4) request comment and information on existing uses of lead that would assist in supporting EPA's selection of proposed criteria for defining significant new uses of lead. Public comments in response to this proposal were to be received by EPA on or before November 28, 1994.

In November, HUD and EPA, acting under the Residential Lead-Based Paint Hazard Reduction Act of 1992, jointly issued a proposed regulation requiring the disclosure of certain information by persons selling or leasing (including renting) housing that may contain lead-based paint hazards. Specifically, these persons, or agents acting in their behalf, would be required to provide purchasers and lessees with all information known to the sellers and lessors on the presence of lead-based paint hazards, as well as provide an EPA information pamphlet pertaining to such hazards. In addition, sellers would be required to grant purchasers 10 calendar days to conduct an inspection or risk assessment for lead-based paint hazards before being obligated under any contract to purchase that housing. Furthermore, the regulation would require that a standard warning, disclosure, and acknowledgment form be attached to all sales and lease contracts involving target housing.

Production

Primary.—In 1994, domestic mine production of lead increased by slightly more than 8,000 mt, or 2%, from the 1993 level, following a 3-year decline. Loss of production as a result of the closure of Cominco American Inc.'s Magmont Mine in Bixby, MO, in early 1994 was countered by an increase in production at other major mines in Missouri and Alaska. Missouri's share of the total mined lead production was 80%, about 3% higher than in 1993. Production in Alaska, Idaho, and Montana accounted for an additional 19% of U.S. mine output. The top 10 mines listed in table 3 produced more than 98% of the total. Domestic mine production data were developed by the U.S. Bureau of Mines (USBM) from a voluntary survey on Lode-Mine Production of Gold, Silver, Copper, Lead, and Zinc. All of the major lead producing mines responded to this survey. *(See tables 1, 2, and 3.)*

The Doe Run Co., St. Louis, MO, a wholly owned subsidiary of Fluor Corp., Irvine, CA, was sold to The Renco Group, a New-York based, privately held company, in early April 1994. According to Doe Run officials, The Renco Group's past record of focusing on diversity and growth in basic industries was complimentary to Doe Run's long term strategy. The Renco Group is a holding company with investments in natural resources and industrial operations. During 1994, Doe Run operated five lead mines and four mills centered around Southeastern Missouri, supplying concentrates to its smelter and refinery at Herculaneum, MO.

Cominco American Inc., Spokane, WA, operator of the Magmont Mine, Bixby, MO, permanently closed the mine at the end of May 1994. The reasons stated for the closure were the depletion of minable ore reserves and the lack of discovery of additional ore reserves. The Magmont Mine, a joint venture between Cominco American and Dresser Industries, Houston, TX, was opened in 1968 and was initially scheduled to be operated for only 12 to 15 years. Subsequent discovery of additional ore reserves permitted the mine to be operated for a total of 26 years. According to the Annual Report of the parent company, Cominco Ltd., Vancouver, B.C., Canada, approximately 23.8 Mmt of ore, grading 7.5% lead, were mined during that period. At yearend, Magmont held 8,373 tons of lead concentrate in inventory for subsequent sale until the inventory is depleted.

Cominco Alaska Inc., a wholly owned subsidiary of the NANA Regional Corp., operated the Red Dog zinc-lead mine in northwest Alaska under a leasing agreement with NANA. The latter is a corporation organized under the provisions of the Alaska Native Claims Settlement Act. According to the Cominco Ltd. Annual Report, the total zinc and lead concentrates produced at Red Dog during 1994 increased by about 25%. Contributing to this increase was the completion of an expanded grinding circuit in late 1994. Concentrates produced at Red Dog were shipped to customers in Canada, Japan, the Republic of Korea, and Europe.

Asarco Incorporated, New York, operated two mines in southern Missouri that produced more than 90% of the concentrate feed for its nearby Glover, MO, smelter and refinery. Production of lead in concentrates at the mines was 119 thousand metric tons (Kmt) in 1994, down about 3% from the record 1993 production level, according to the company's annual report to stockholders. Refinery production at the Glover facility set a record of 133 mt of lead in 1994, as the Glover refinery implemented new operating and maintenance programs which allowed it to produce in excess of design capacity. Asarco also operated a custom primary lead business, processing concentrates from other producers at its East Helena, MT, smelter and Omaha, NE, refinery. This custom processing circuit was largely dependent upon the purchase of concentrates from mines in the United States and South America for its source of processing material. A small portion of its feed came from Asarco's mines in Leadville, CO, and Quiruvilca, Peru. In 1994, transportation delays affected concentrate shipments from South America, and a temporary shutdown by the principal U.S. supplier terminated shipments for 4 months. As a result, production at the East Helena smelter was down in 1994, thus prompting the purchase of lead bullion to maintain production levels at the Omaha refinery. *(See table 4.)*

Asarco, reportedly, also began upgrading its East Helena smelter in 1994. The project, started in early April, was being carried out by JSG Technical Services Inc., Goshen, NY. It focused on the design and upgrading of fume and dust control and materials handling systems in the manufacturing facility. At yearend, Asarco reported total lead reserves in Missouri of 16.3 Mmt, with 11.2 million tons, grading 4.78% lead at Sweetwater and 5.1 million tons grading 5.56% lead at West Fork.

The Burgin lead/zinc/silver mine, southwest of Salt Lake City, UT, was under consideration for reopening, pending results of a drilling program to expand proven reserves, and an economic feasibility study to determine the costs of reopening the mine. Chief Consolidated Mining Co., Eureka, UT, owner of the mine since 1992, expected to complete the drilling program in April 1995. The Burgin Mine was last operated in 1978 by Kennecott Copper Corp.

Secondary.—Domestic secondary production in 1994 was estimated to have increased by about 2% compared with that of revised 1993 figures. Secondary lead accounted for 72% of domestic lead refinery production, reflecting a continued high level of lead-acid battery recycling. Lead recovered from scrap lead-acid batteries accounted for 89% of all lead produced from secondary sources during 1994. The domestic secondary statistics were developed by the USBM from a combined secondary producer and consumer survey, that included data from both monthly and annual respondents. Of the 174 consuming companies to which a survey request was sent, 139 responded, representing 88% of the total U.S. lead consumption. Of the 24 companies producing secondary lead, exclusive of that produced from copper-based scrap, to which a survey request was sent, 21 responded, representing 91% of the total refinery production of secondary lead. Production and consumption for the nonrespondents were estimated using prior year levels as a basis. *(See tables 1, 5, 6, 7, 8, and 9.)*

GNB Battery Technologies Inc., Atlanta, GA, received approval from the Georgia EPA early in 1994 to build and operate a new and expanded lead-acid battery recycling facility at its present Columbus, GA, location. The new secondary smelter/refinery, expected to be completed in mid-1995, will have a production capacity of 90,000 tons per year of lead, 4.5 times that of the existing plant at the Columbus site. GNB also acquired Quenell Enterprises, a Los Angeles-based lead oxide producer, in October 1994. This purchase reportedly was intended to further support GNB's growing in-house demands in battery production, recycling, and distribution associated with the opening of the new Columbus plant.

GNB's decision to build its new facility at the Columbus location followed an announcement in late 1993 that it was suspending indefinitely plans for a proposed greenfield secondary lead smelter in Waynesboro, GA. According to GNB officials, however, the company was still considering construction of a secondary smelter at the Waynesboro location that would be similar to the new Columbus facility.

Exide Corp., Reading, PA, began construction of a new 35,000 unit-per-day lead-acid battery manufacturing plant in Bristol, TN, during the first quarter of 1994. The 500,000-square-foot facility will employ as many as 1,000 people when its anticipated full production capacity is reached in early 1995. Exide expects to use secondary lead as its principle feedstock, but may also use some domestic or imported primary lead to supplement the secondary metal.

In September, RSR Corp., Dallas, TX, suspended the process of obtaining permits for its planned $60 million battery recycling plant in Aiken County, SC. The suspension of such activity was made at the request of the Aiken County Economic Development Partnership, pending the outcome of a federal grand jury indictment alleging environmental violations at RSR's Indianapolis, IN, recycling plant.

Consumption

Reported consumption of lead increased by about 13% in 1994. This increase was due to a 13% increase in demand for SLI batteries. Most of this increase was in the demand for replacement batteries that resulted from the abnormally harsh 1993-94 winter nationwide. Consumption of lead in all forms of lead-acid batteries represented 84% of the total reported consumption of lead in 1994.

The Battery Council International reported a 1994 SLI battery production of 97.5 million units, compared with 86.0 million units in 1993 and 81.1 million units in 1992. The totals include both original equipment and replacement automotive-type batteries. Using an estimate of 10.6 kilograms (23.3 pounds) per unit, the SLI offtake for 1994 was about 1.03 Mmt of lead. SLI batteries include those used for buses and trucks, tractors, marine, golf carts, motorcycles, aircraft, mine equipment, floor care, and military equipment. Lead consumption in lead-acid batteries for uses other than SLI, such as for stationary, industrial, and motive power applications, was 190,000 tons in 1994. *(See tables 6, 7, 8, 9, 12, 13, 14, and 15.)*

World Review

Statistics published by the International Lead and Zinc Study Group (ILZSG) indicated that world production of refined lead decreased to 5.3 million tons and world consumption increased to 5.3 million tons in 1994 from about 5.4 million tons and 5.2 million tons, respectively, in 1993. Worldwide commercial stocks of refined lead subsequently declined to 0.77 million tons, or 7 weeks of world consumption, at yearend 1994. This compared with 0.79 million tons, or 8 weeks of consumption, at yearend 1993, 0.74 million tons, or 7 weeks of consumption, at yearend 1992, and 0.58 million tons, or 5 weeks of consumption, at yearend 1991.[1]

Significant exports of lead to Western consumers from Eastern countries, notably China, continued during 1994. Lead prices increased steadily throughout 1994, continuing the increase that began in the last half of 1993. The average annual LME and North American producer prices were up by $0.064 and $0.054 per pound, respectively, compared with average prices in 1993.

During 1994, two mines and one primary smelter-refinery were reopened, as a consequence of the increasing demand and rising prices for lead. Brunswick Mining and Smelting Corp. Ltd., Toronto, Canada, reopened its Belledune plant in New Brunswick in January. The plant had been closed in late 1993 owing to insufficient concentrate supplies as a result of the temporary closure of the company's nearby Brunswick Mine and the indefinite closure of its Heath Steele Mine, also in New Brunswick. Belledune derived about 80% of its concentrates from these two mines. In May, the company announced plans to reopen its Heath Steele Mine in late 1994. At full capacity, the Health Steele Mine will produce 10,000 tons per year of lead in concentrate. Noranda, Inc., Toronto, Canada, owns a 75% stake in Heath Steele and Brunswick a 25% share.

In Mexico, Mineral Real de Angeles' (MRA) polymetallic mine in Zacatecas State reopened near the beginning of the year at a reduced rate of operation. The MRA mine had been closed since April 1993 because of the depressed market. MRA produced 45,000 tons of lead in 1992 and had produced about 15,000 tons in 1993 before it was closed.

During 1994, the sale of two significant lead mining interests occurred in Australia. In April, BHP Minerals, Melbourne, Australia, sold its 58% interest in the Cadjebut lead/zinc mining operation in Western Australia to an unlisted private company, Western Metals. About 22,000 mt of lead were produced at the mine in 1993. The ore body reserves at Cadjebut were expected to be depleted by yearend 1995, but the sales transaction reportedly included the nearby Blendevale, Twelve Mile Bore and Kapok deposits, which had significant development potential. In May, CRA Ltd., Melbourne, Australia, sold a 38.9% interest in the lead/zinc producer Pasminco Ltd. to a large number of local and international institutional investors, but retained its remaining 10% interest until a suitable buyer was located. According to CRA officials, the sale was made to release funds for CRA to develop the significant Century zinc/lead/silver deposit in Northern Queensland, Australia. Century has indicated resources of 118 Mmt containing 10.2% zinc, 1.5% lead, and 36 grams per metric ton silver. Full development of the Century project was expected to take about 3 years with initial production scheduled for 1998. An environmental impact assessment, a feasibility study, and a bulk ore sampling evaluation were in progress at yearend.

Arcon International Resources, Dublin, Ireland, received final state approval in April for the development of its Galmoy zinc-lead deposit in County Kilkenny, Ireland. Subsequently, Arcon reached agreement with the state on the terms and conditions for acquiring a state mining license. Under the terms of the licensing agreement, significant potential will exist for additional mineral discoveries at Galmoy, where, at present, only 3% of the licensed area has been explored. Production of concentrate at the Galmoy facility was expected to begin in late 1996. The operators anticipated a mine life of approximately 10 years at a 10,000-ton-per-year lead concentrate production rate.

During 1994, the Organization for Economic Cooperation and Development (OECD) continued its discussions on means whereby the hazard to lead exposure might be reduced worldwide. Significant effort was directed toward the formulation of a possible lead risk reduction council act that would impose certain standards on the uses of lead, and could be supported by the OECD member countries. The OECD working group involved in the council act formulation began the process by consolidating the views of OECD member countries as identified in a draft outline prepared at the Joint Chemicals Group and Management Committee Meeting in February 1994 in Paris, France. Specifically, the working group examined the products/uses of lead identified in the outline as candidates for standardization, and considered comments by member countries pertaining to nonproduct issues and action programs described in the outline. Subsequently, the working group prepared a lead risk reduction proposal for consideration at a workshop on lead products and uses held in September 1994 in Toronto, Canada.

In a response to this proposal, the Australian Bureau of Agricultural and

Resources Economics (ABARE) reported on a study in which they provided an economic perspective on the risk reduction strategy being considered by the OECD. The ABARE study concluded that the imposition of lead exposure standards in OECD member countries would adversely affect base metal mining and lead processing industries, effectively reducing demand for lead and lowering prices while pushing costs higher. Furthermore, if lead prices declined, the incentive to recycle lead would fall. Such a result would be counter to the development of efficient and sustainable recycling industries capable of reducing the risk of exposure to lead.

Following the workshop in Toronto, the Joint Chemicals Group and Management Committee met in Paris in November 1994, where the OECD participants agreed to proceed with the preparation of a draft council act on lead risk reduction. By yearend, technical issues pertaining to the draft act were continuing to be discussed.

Mine Capacity.—During 1994, three lead-producing mines were opened and another closed. Metall Mining produced its first concentrates from the Bougrine lead/zinc mine in the Tunisian State of Kaf in early May 1994. Metall Mining, a Canadian-based subsidiary of Metallgesellschaft AG, Germany, owns a 45% share in the mine, which is operated jointly with Tunisian mining interests. Production of lead concentrates was expected to reach 14,000 tons annually. In Mexico, concentrate production was begun in August at the Tizapa lead-zinc mine in the Zacazonapan mining area. Production at Tizapa, developed by the Japanese-Mexican joint venture Minera Tizapa, was expected to reach 950 tons of lead concentrate per month according to an official from Dowa Mining Co., the Japanese company which holds a 39% interest in the mining venture. Japan's Sumitomo Corp. owns a 10% stake in the venture and Mexico's Industria Penoles SA de CV owns the remaining 51% interest in Minera Tizapa. The lead concentrates produced at Tizapa were to be smelted by Penoles in Mexico. Rights to development of the Tizapa Mine by the joint-venture company had been awarded in March 1992. In China, the Changba lead/zinc mine in the northern Province of Gansu came on-stream at the beginning of the year with a production capacity of 1,800 mt per year of lead in concentrate. According to China National Nonferrous Metals Import and Export Corp., the capacity of Changba will be increased to 5,000 metric tons per year by yearend 1996. At yearend 1994, two other lead/zinc mines in China, Lijiagou in the northern Province of Gansu and Lanping in the southern Province of Yunnan, were awaiting approval from Government authorities to proceed with production plans.

Zambia's state-owned mining group Zambia Consolidated Copper Mines (ZCCM) closed its lead/zinc mine in Kabwe at the end of June 1994, citing increasing financial losses resulting from declining production and rising costs of operation. Production of lead at the mine was estimated to be near 8,000 mt in 1993. Through mid-April 1994, about 2,330 tons of lead in concentrate were produced at the mine. At yearend, ZCCM provided public notice that it was accepting bids on the sale of all the Kabwe assets. *(See table 10.)*

Metal Capacity.—In April 1994, Mitsubishi Metal Corp. closed its 42,000-ton-per-year capacity primary smelter and refinery on Naoshima Island, in the Sea of Japan. At the time of closure, Naoshima was producing lead at a rate of about 3,000 tons per month. The decision to close the facility was based on a combination of factors, including low lead prices, the rise in the value of the yen, and less expensive lead imports. Starting in July 1995, the import duty paid on refined lead was expected to be reduced progressively from the existing $70 per ton to $24 per ton by the year 2000.

Australia's MIM Holdings Ltd. (MIM) closed indefinitely its 60,000-ton-per-year ISASMELT primary smelter at Mount Isa in the beginning of the year. The action was taken principally due to insufficient concentrate feed from the Mount Isa mill for full utilization of both the conventional sintering and blast furnace smelter and the ISASMELT smelter. MIM had decided in late 1992 to restrict mine output to 85% of full production. Consequently the stockpiled concentrate that had provided additional feed to maintain the ISASMELT facility became depleted at the start of the year. Before the closure, the smelting complex was operated at a production rate of 16,000 to 17,000 tons per month of lead bullion. Operation of the conventional smelter was continued during the year, producing bullion at a rate about 2,000 tons per month lower then the previous combined rate of the two smelters. Discussions were carried out during the year between MIM and BHP Minerals Ltd., Melbourne, Australia, for MIM to acquire an appreciable interest in the Cannington lead/silver mining project in Queensland, Australia. It was anticipated that, should the acquisition be agreed upon by the companies, it would enable MIM to eventually gain an additional source of concentrate to reopen the ISASMELT plant.

Oriental Technique, a Malaysian-Korean joint-venture company, began production of lead at its new secondary lead smelter near the end of the year. The smelter, with a production capacity of about 1,500 metric tons per month, is located at Port Klang, Selangor, in West Malaysia. The company planned to acquire a significant portion of its lead scrap feed material from local sources.

During 1994, the capacity of the Zhuzhou primary lead smelter, Zhuzhou, Hunan Province, China, reportedly was increased from the current 70,000 tons per year of lead to 80,000 tons per year. In recent years, Zhuzhou received a significant portion of its concentrates from the Fankou Mine, Guangdong Province. In 1994, however, the company began to buy concentrate from several local open pit mines after the price of concentrate from Fankou became unsatisfactory. *(See table 11.)*

Reserves.—Worldwide reserves of lead contained in demonstrated resources from both producing and nonproducing deposits at yearend were estimated at 68 million tons by the USBM. Reserves for the two largest producers in the Western world, Australia and the United States, were about 19 million and 8 million tons, respectively. Canada, the fifth largest producer in the world in 1994, had reserves of 4 million tons. China, the third leading producer in 1994, had reserves of 7 million tons. The reserve base (reserves plus marginal economic deposits, measured and indicated) for Australia and the United States was 34 million tons and 20 million tons, respectively. In Canada, the reserve base was 13 million tons and in China, 11 million tons. Total world reserve base at the end of 1994 was estimated to be 124 million tons.

Outlook

The rate of economic growth in the United States is expected to decline in 1995, with the gross domestic product (GDP) growing at a rate of 2.5% to 3.0%, compared with a rate of about 4.1% in 1994. The automotive manufacturing sector, nonetheless, is expected to remain relatively strong during 1995, resulting in a higher demand for original equipment batteries. The U.S. new vehicle production is anticipated to increase by 5.7%, to 12.9 million units in 1995. Countering this increase in the demand for new lead-acid batteries, however, is an expected decrease in the demand for replacement batteries. Consumption of lead in replacement batteries was particularly strong in 1994 owing to the harsh 1993-94 winter nationwide. The net result is a predicted moderate decrease of 1% to 2% in overall lead demand during 1995.

Domestic mine production should increase by about 4% in 1995 as a result of continued higher production at some of the larger facilities. Total metal production from primary and secondary refineries is expected to show a net decline of about 1%, mainly because of a slight decline in available scrap for the secondary sector.

The tighter world lead market of 1994 is likely to begin easing somewhat in 1995 because world consumption is expected to remain static while world production is predicted to increase marginally. The latter increase is related to planned expansion in metal production in Europe, Canada, and the Republic of Korea. The expansion will be dependent, however, on adequate supplies of secondary materials from Eastern bloc countries.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Lead. Ch. in Mineral Commodity Summaries, annual.

Lead. Mineral Industry Surveys, monthly.

Other Sources

ABMS Non-Ferrous Metal Data.

American Metal Market (daily paper).

International Lead and Zinc Study Group (ILZSG), special reports.

International Lead-Zinc Research Organization (ILZRO).

Lead Industries Association, Inc.

Metal Bulletin (London).

Platt's Metals Week.

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[1] International Lead and Zinc Study Group (London). Lead and Zinc Statistics. Monthly Bull., v. 35, No. 6, June 1995.

TABLE 1
SALIENT LEAD STATISTICS 1/

(Metric tons unless otherwise specified)

		1990	1991	1992	1993	1994
United States:						
Production:						
Domestic ores, recoverable lead content		484,000	466,000	397,000	355,000	363,000
Value	thousands	$491,000	$344,000	$307,000	$249,000	$298,000
Primary lead (refined):						
From domestic ores and base bullion		386,000	324,000	284,000	310,000	328,000
From foreign ores and base bullion		18,000	21,900	20,800	24,900	23,400
Secondary lead (lead content)		922,000	885,000	916,000	893,000 r/	913,000
Exports (lead content):						
Lead ore and concentrates		56,600	88,000	72,300	41,800	38,700
Lead materials, excluding scrap		76,700	114,000	71,700	60,300	74,200
Imports for consumption:						
Lead in ore and concentrates		10,700	12,400	5,310	483	473
Lead in base bullion		2,710	419	218	18	577
Lead in pigs, bars, and reclaimed scrap		90,900	117,000	191,000	196,000	231,000
Stocks, Dec. 31:						
Primary lead 2/		25,500	9,090	20,500	14,300	9,270
At consumers and secondary smelters		86,300	71,700	82,300	80,500 r/	67,500
Consumption of metal, primary and secondary		1,280,000	1,250,000	1,240,000	1,290,000 r/	1,450,000
Price: Metals Week average, delivered, cents per pound		46.02	33.48	35.10	31.74	37.17
World:						
Production:						
Mine	thousand metric tons	3,370 r/	3,330 r/	3,080 r/	2,830 r/	2,800 e/
Refinery 3/	do.	3,090	3,080 r/	2,950 r/	3,050 r/	2,970 e/
Secondary refinery	do.	2,860 r/	2,690	2,480	2,400 r/	2,420 e/
Price: London Metal Exchange, pure lead, cash average, cents per pound		37.05	25.30	24.50	18.42	24.83

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ American Bureau of Metal Statistics Inc.

3/ Primary metal production only; includes secondary metal production, where inseparable.

TABLE 2
MINE PRODUCTION OF RECOVERABLE LEAD IN THE UNITED STATES, BY STATE 1/

(Metric tons)

State	1993	1994
Missouri	277,000	290,000
Montana	W	9,940
Other States 2/	77,800	63,100
Total	355,000	363,000

W Withheld to avoid disclosing company proprietary data; included in "Other States."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes Alaska, Arizona, Colorado, Idaho, Illinois, New York, Tennessee, and Washington.

TABLE 3
LEADING LEAD-PRODUCING MINES IN THE UNITED STATES IN 1994, IN ORDER OF OUTPUT

Rank	Mine	County and State	Operator	Source of lead
1	Sweetwater	Reynolds, MO	ASARCO Incorporated	Lead ore.
2	Fletcher	do.	The Doe Run Co.	Lead-zinc ore.
3	West Fork	do.	ASARCO Incorporated	Lead ore.
4	Casteel 1/	Iron, MO	The Doe Run Co.	Lead-zinc ore.
5	Red Dog	Northwest Arctic, AK	Cominco Alaska Inc.	Zinc ore.
6	Buick	Iron, MO	The Doe Run Co.	Lead-zinc ore.
7	Viburnum No. 29	Washington, MO	The Doe Run Co.	Do.
8	Magmont	Iron, MO	Cominco American Inc.	Lead ore.
9	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Lead-zinc ore.
10	Montana Tunnels	Jefferson, MT	Pegasus Gold Corp.	Zinc ore.
11	Leadville Unit	Lake, CO	ASARCO Incorporated	Do.
12	Balmat	St. Lawrence, NY	Zinc Corporation of America	Zinc ore.
13	Viburnum No. 28	Iron, MO	The Doe Run Co.	Lead-zinc ore.
14	Pierrepont	St. Lawrence, NY	Zinc Corporation of America	Zinc ore.
15	Rosiclare	Hardin, IL	Ozark-Mahoning Co.	Fluorspar.
16	Coy	Jefferson, TN	ASARCO Incorporated	Zinc ore.

1/ Includes Brushy Creek Mill.

TABLE 4
REFINED LEAD PRODUCED AT PRIMARY REFINERIES IN THE UNITED STATES, BY SOURCE MATERIAL 1/

(Metric tons unless otherwise specified)

Source material		1993 2/	1994 3/
Refined lead:			
Domestic ores and base bullion		310,000	328,000
Foreign ores and base bullion		24,900	23,400
Total		335,000	351,000
Calculated value of primary refined lead 4/	thousands	$234,000	$288,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Total refined lead: American Bureau of Metal Statistics Inc.; domestic and foreign ores: U.S. Bureau of Mines calculations.

3/ U.S. Bureau of Mines reported figures.

4/ Value based on average quoted price.

TABLE 5
LEAD RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY 1/

(Metric tons)

	1993	1994
KIND OF SCRAP		
New scrap:		
Lead-base	48,200 r/	47,100
Copper-base	6,870 r/	8,000 e/
Tin-base	(2/)	--
Total	55,000 r/	55,100
Old scrap:		
Battery-lead	796,000 r/	816,000
All other lead-base	33,500 r/	33,800
Copper-base	8,780 r/	8,000 e/
Tin-base	--	--
Total	838,000 r/	858,000
Grand total	893,000 r/	913,000
FORM OF RECOVERY		
As soft lead	444,000 r/	510,000
In antimonial lead	417,000 r/	371,000
In other lead alloys	17,000	16,100
In copper-base alloys	15,600 r/	16,000 e/
In tin-base alloys	(2/)	1
Total	893,000 r/	913,000
Value 3/ thousands	$625,000 r/	$748,000

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Revised to zero.

3/ Value based on average quoted price of common lead.

TABLE 6
U.S. CONSUMPTION OF LEAD, BY PRODUCT 1/

(Metric tons)

SIC Code	Product	1993	1994
	Metal products:		
3482	Ammunition: Shot and bullets	65,100	62,400
	Bearing metals:		
35	Machinery except electrical	W	W
36	Electrical and electronic equipment	425	288
371	Motor vehicles and equipment	3,510 2/	4,190 2/
37	Other transportation equipment	W	W
	Total bearing metals	4,830	5,560
3351	Brass and bronze: Billets and ingots	5,750 r/	6,320
36	Cable covering: Power and communication	17,200	16,000
15	Calking lead: Building construction	961	764
	Casting metals:		
36	Electrical machinery and equipment	W	W
371	Motor vehicles and equipment	W	W
37	Other transportation equipment	2,460	2,650
3443	Nuclear radiation shielding	W	W
	Total casting metals	18,500	18,900
	Pipes, traps, other extruded products:		
15	Building construction	5,740	3,370
3443	Storage tanks, process vessels, etc.	(3/)	(3/)
	Total pipes, traps, other extruded products	5,740	3,370
	Sheet lead:		
15	Building construction	15,200	14,900
3443	Storage tanks, process vessels, etc.	(3/)	(3/)
3693	Medical radiation shielding	6,030	6,620
	Total sheet lead	21,200	21,500
	Solder:		
15	Building construction	3,290	2,680
	Motor vehicles, equipment, metal cans and shipping containers	4,970	3,020
367	Electronic components and accessories	4,890	5,530
36	Other electrical machinery and equipment	1,240	1,180
	Total solder	14,400	12,400
	Storage batteries:		
3691	Storage battery grids, post, etc.	677,000 r/	802,000
3691	Storage battery oxides	374,000 r/	419,000
	Total storage batteries	1,050,000 r/	1,220,000
371	Terne metal: Motor vehicles and equipment	(4/)	(4/)
27	Type metal: Printing and allied industries	(5/)	(5/)
34	Other metal products 6/	5,360	5,330
	Total metal products	1,210,000 r/	1,370,000
	Other oxides:		
285	Paint	W	W
32	Glass and ceramics products	W	W
28	Other pigments and chemicals	9,870	10,200
	Total other oxides	63,600	62,700
	Miscellaneous uses	11,800	12,000
	Grand total	1,290,000 r/	1,450,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in appropriate totals.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes "Terne metal: Motor vehicles and equipment."

3/ Included with "Building construction" to avoid disclosing company proprietary data.

4/ Included with "Bearing metals: Motor vehicles and equipment."

5/ Included with "Other metal products" to avoid disclosing company proprietary data.

6/ Includes lead consumed in foil, collapsible tubes, annealing, galvanizing, plating, and fishing weights.

TABLE 7
U.S. CONSUMPTION OF LEAD IN 1994, BY STATE 1/ 2/

(Metric tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California, Oregon, and Washington	54,300	37,000	15,500	--	107,000
Florida and Georgia	21,400	15,200	2,480	--	39,000
Illinois	24,100	43,400	9,570	544	77,600
Iowa, Michigan, and Missouri	56,500	49,900	16,700	--	123,000
Ohio and Pennsylvania	122,000	76,800	50,400	1,180	250,000
Arkansas and Texas	84,500	63,000	16,300	--	164,000
Alabama, Louisiana, Mississippi, and Oklahoma	19,200	6,760	20,500	--	46,500
Colorado, Indiana, Kansas, Kentucky, Minnesota, Nebraska, Tennessee, and Wisconsin	266,000	100,000	74,600	1,120	442,000
Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Rhode Island, South Carolina, and Vermont	103,000	61,200	35,700	--	200,000
Total	750,000	453,000	242,000	2,840	1,450,000

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes lead that went directly from scrap to fabricated products.

TABLE 8
U.S. CONSUMPTION OF LEAD IN 1994, BY CLASS OF PRODUCT 1/ 2/

(Metric tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	59,600	71,500	18,600	2,840	153,000
Storage batteries	620,000	381,000	221,000	--	1,220,000
Other oxides	62,700	3	--	--	62,700
Miscellaneous	8,460	1,420	2,160	--	12,000
Total	750,000	453,000	242,000	2,840	1,450,000

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes lead that went directly from scrap to fabricated products.

TABLE 9
STOCKS OF LEAD AT CONSUMERS AND SECONDARY SMELTERS IN THE UNITED STATES, DECEMBER 31 1/

(Metric tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1993	39,300 r/	33,900 r/	7,200 r/	120	80,500 r/
1994	32,900	26,300	8,080	175	67,500

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 10
LEAD: WORLD MINE PRODUCTION OF LEAD IN CONCENTRATES, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Algeria e/	1,100	900	900	900	900
Argentina	23,400	23,700	18,000	11,800 r/	12,000
Australia	570,000	579,000	577,000 r/	519,000 r/	537,000
Austria	1,490	1,150	920	1,340 r/	--
Bolivia	19,900	20,800	20,000	21,200 r/	19,600
Bosnia and Herzegovina e/	XX	XX	2,000	400	500
Brazil	9,290	7,270	2,520 r/	2,500 r/ e/	2,000
Bulgaria e/	57,000	43,600	39,000	39,000	40,000
Burma e/	2,700 r/	2,750 r/	2,800 r/	2,200 r/	2,300
Canada	241,000	277,000	344,000	183,000 r/	172,000 4/
Chile	1,120	1,050	298	343 r/	350
China e/	315,000	352,000	330,000	338,000 r/	340,000
Colombia	331	611	620 r/	447 r/	440
Czech Republic	XX	XX	XX	1,000 e/	1,000
Czechoslovakia e/ 5/	3,040	3,430	2,800	XX	XX
Ecuador e/	200	200	200	200	200
Finland	1,700	1,400 r/	576	-- r/	--
France	1,190	1,730	--	--	--
Georgia e/	XX	XX	800	500	400
Germany: Western states	7,150	5,930	1,490	--	--
Greece	26,200	31,700	28,300	26,400 r/	22,800 4/
Greenland	16,000	--	--	--	--
Honduras	5,790	8,720	10,800 r/	3,550 r/	2,810 4/
India	23,200	25,100	30,500 r/	26,000 r/	23,300 4/
Iran e/ 6/	11,000	16,000	25,000	25,000	30,000
Ireland	35,300	39,900	42,900	44,600 r/	45,000
Italy	16,000	14,200	16,000 e/	7,400 r/ e/	6,500
Japan	18,700	18,300	18,800	16,500	9,950 4/
Kazakhstan e/	XX	XX	170,000	160,000	140,000
Korea, North e/	80,000	80,000	75,000	80,000	80,000
Korea, Republic of	14,900	12,600	13,600	14,800 r/ e/	15,000
Macedonia e/	XX	XX	15,000	15,000	15,000
Mexico	187,000	168,000	170,000	154,000 r/	170,000
Morocco	68,800	73,700	76,600	81,700 r/	73,200 4/
Namibia e/	18,000	15,000	15,000	11,600 r/ 4/	13,000 4/
Nigeria e/	106	100	100	100	100
Norway	3,020	3,520	3,770	1,700 r/	3,160 4/
Peru	210,000 r/	218,000 r/	196,000 r/	217,000 r/	220,000
Poland	61,300	63,600	63,000	63,000 e/	63,000
Romania	24,700	16,200	16,800	16,800 e/	16,800
Russia e/	XX	XX	40,000	50,000	40,000
Saudi Arabia e/	250	250	250	250	250
Serbia and Montenegro	XX	XX	20,000	20,000 e/	20,000
Slovakia	XX	XX	XX	1,800 e/	1,800
Slovenia e/	XX	XX	2,000	--	2,000
South Africa, Republic of	69,400	76,300	75,800	100,000 r/	95,800 4/
Spain	58,500	49,200 r/	31,000 r/	25,300 r/	26,000
Sweden	98,300	91,100	105,000 r/	112,000 r/	113,000 4/
Tajikistan e/	XX	XX	2,000	1,600	1,200
Thailand	22,200	16,700	11,900 r/	6,050 r/	7,950
Tunisia	2,970	1,290	1,360	1,300 e/	1,300
Turkey	18,400	15,300	10,800 e/	10,900 r/	11,000
U.S.S.R. 7/	420,000	380,000	XX	XX	XX
United Kingdom	1,380	1,020	500 r/ e/	240 r/	--
United States	497,000	477,000	407,000	362,000	370,000 4/
Uzbekistan e/	XX	XX	40,000	40,000	35,000
Yugoslavia 8/	99,100	90,000 e/	XX	XX	XX
Zambia 9/	9,640	9,080	4,450 r/	7,030 r/	--
Total	3,370,000 r/	3,330,000 r/	3,080,000 r/	2,830,000 r/	2,800,000

See footnotes at end of table.

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 6, 1995.

3/ In addition to the countries listed, Uganda may produce lead, but available information is inadequate to make reliable estimates of output levels.

4/ Reported figure.

5/ Dissolved Dec. 31, 1992. Production from 1990-92 came from the Czech Republic and Slovakia.

6/ Year beginning Mar. 21 of that stated.

7/ Dissolved in Dec. 1991.

8/ Dissolved in Apr. 1992.

9/ Pb content of ore milled in year beginning Apr. 1 of that stated. Mine closed in June 1994.

TABLE 11
LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Algeria: e/					
Primary	1,000	1,000	1,000	1,500 r/	1,500
Secondary	3,500	3,500	3,500	3,500 r/	3,500
Total	4,500	4,500	4,500	5,000	5,000
Argentina:					
Primary e/	10,000	10,000	14,600 3/	15,000	15,000
Secondary	13,400	13,700	15,000 e/	14,500 e/	14,000
Total e/	23,400	23,700	29,600	29,500	29,000
Australia:					
Primary	212,000	220,000	215,000	221,000 r/	209,000
Secondary	17,000	19,000	17,000	22,000 r/	17,000
Total	229,000	239,000	232,000	243,000 r/	226,000
Austria:					
Primary	8,390	6,350	5,730	4,780 r/	--
Secondary	15,100	16,300	18,200	17,900 r/	17,000
Total	23,500	22,700	23,900	22,700 r/	17,000
Belgium:					
Primary	68,800	78,100	75,300	75,900 r/	75,000
Secondary	37,000	32,600	41,000	51,000 r/	60,000
Total	106,000	111,000	116,000	127,000 r/	135,000
Brazil:					
Primary	30,100	22,000	24,500 r/	27,700 r/	30,000
Secondary	45,300	42,000	38,300 r/	47,000 r/	45,000
Total	75,400	64,000	62,800 r/	74,700 r/	75,000
Bulgaria:					
Primary e/	56,000	46,000	43,000 r/	45,000	45,000
Secondary e/	10,600	10,200	10,100 r/	10,000	10,000
Total	66,600	56,200	53,100 r/	55,000 e/	55,000
Burma: Primary	1,690 r/	2,180	2,120	1,560 r/	1,450
Canada:					
Primary	87,200	106,000	151,000 r/	151,000 r/	150,000
Secondary	96,500	106,000	102,000 r/	69,100 r/	70,000
Total	184,000	212,000	253,000 r/	220,000 r/	220,000
China: e/					
Primary	266,000	290,000	325,000	372,000 r/	367,000
Secondary	30,000	40,000	40,000	40,000	40,000
Total	296,000	330,000	365,000	412,000 r/	407,000
Colombia: Secondary e/	3,500	3,600	3,600	3,600	3,500
Czech Republic: Secondary e/	XX	XX	XX	20,000	20,000
Czechoslovakia: 4/ Secondary	23,700	17,800	24,000	XX	XX
France:					
Primary	162,000	155,000	161,000 e/	158,000 e/	160,000
Secondary e/	270,000 3/	284,000	284,000	280,000	284,000
Total e/	432,000 r/	439,000 r/	445,000	438,000	444,000
Germany:					
Primary:					
Eastern states e/	15,800	XX	XX	XX	XX
Western states	162,000	XX	XX	XX	XX
Total primary	178,000 e/	161,000 r/	175,000	175,000 r/	189,000 3/
Secondary:					
Eastern states 5/	45,500 r/	XX	XX	XX	XX
Western states	187,000	XX	XX	XX	XX
Total secondary	233,000 r/	202,000	179,000	160,000 r/	142,000 3/
Total Germany	411,000 r/	363,000 r/	354,000	335,000	331,000 3/
Guatemala: Secondary	-- r/	-- r/	-- r/	-- r/	--
Hungary: Secondary e/	100	100	100	100	100
India: e/					
Primary	29,900 3/	30,600 r/	40,800 r/	43,200 r/	29,400
Secondary	16,800 3/	17,200 r/	22,900 r/	24,200 r/	16,500
Total	46,700 3/	47,800 r/	63,700 r/	67,400 r/	45,900 3/
Iran:					
Primary	--	--	--	--	10,000 3/
Secondary e/	10,000	8,000	7,800	8,000	8,000
Total e/	10,000	8,000	7,800	8,000	18,000

See footnotes at end of table.

TABLE 11--Continued
LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Ireland: Secondary	15,000 e/	11,600	12,000	12,000 e/	10,000
Italy:					
Primary	64,600	112,000	102,000	89,900 r/	86,000
Secondary	102,000	96,500	84,300	92,900 r/	94,000
Total	167,000	209,000 r/	186,000	183,000 r/	180,000
Jamaica: Secondary e/	1,000	1,000	1,000	800	800
Japan:					
Primary	205,000	220,000	219,000	212,000 r/	183,000 3/
Secondary	122,000	112,000	111,000	97,300 r/	109,000 3/
Total	327,000	332,000	330,000	309,000 r/	292,000 3/
Kazakhstan: e/					
Primary	XX	XX	180,000	170,000	150,000
Secondary	XX	XX	30,000	25,000	20,000
Total	XX	XX	210,000	195,000	170,000
Korea, North: e/					
Primary	70,000	75,000	70,000	75,000	75,000
Secondary	6,000	5,000	5,000	5,000	5,000
Total	76,000	80,000	75,000	80,000	80,000
Korea, Republic of: e/					
Primary	61,000	40,600 r/	63,000 r/	88,000 r/	76,000
Secondary	14,000	40,000	25,000 r/	10,000 r/	15,000
Total	75,000	80,600 r/	88,000 r/	98,000 r/	91,000
Macedonia: e/					
Primary	XX	XX	6,000	6,000	6,000
Secondary	XX	XX	2,000	2,000	2,000
Total	XX	XX	8,000	8,000	8,000
Malaysia: Secondary e/	16,000	24,000 r/	28,500 r/	29,000 r/	28,800 3/
Mexico:					
Primary	167,000	152,000	167,000 r/	178,000	180,000
Secondary e/	65,000	10,000	10,000	10,000	10,000
Total e/	232,000	162,000	177,000 r/	188,000	190,000
Morocco: e/					
Primary	64,000	70,000	68,000	69,000 r/	69,000
Secondary	2,000	2,000	2,000	2,000	2,000
Total	66,000	72,000	70,000	71,000 r/	71,000
Namibia: Primary 6/	35,100	33,400	31,700	31,200	23,800 3/
Netherlands: Secondary	44,100	33,700	24,300 r/	24,200	25,000
New Zealand: Secondary e/	5,000	5,000	5,000	3,000 r/	3,000
Pakistan: Secondary e/	2,500	2,500	3,000	3,000	3,000
Peru:					
Primary	69,300	74,500	82,500	87,400 r/	87,000
Secondary e/	5,000	5,000	5,000	5,000	5,000
Total e/	74,300	79,500	87,500	92,400 r/	92,000
Philippines: Secondary	12,100	16,100 r/	19,100 r/	24,300 r/	24,300
Poland:					
Primary e/	49,800	35,800	38,700	47,300 r/	46,300
Secondary e/	15,000	15,000	15,000	15,000	15,000
Total	64,800	50,800	53,700	62,300 r/	61,300 3/
Portugal: Secondary e/	6,000	5,000	7,400 r/	8,000 r/	8,000
Romania:					
Primary	15,700	13,200	14,400	10,500 r/	22,000 3/
Secondary e/	5,000	4,000	1,750 3/	1,500	4,000 3/
Total	20,700 e/	17,200 e/	16,200	12,000 r/	26,000 3/
Russia:					
Primary	XX	XX	24,100 r/	31,600 r/	21,000 3/
Secondary e/	XX	XX	40,000	30,000	20,000
Total e/	XX	XX	64,100 r/	61,600 r/	41,000
Serbia and Montenegro:					
Primary	XX	XX	23,300 r/	6,390 r/	4,460 3/
Secondary	XX	XX	390 r/	--	--
Total	XX	XX	23,700 r/	6,390 r/	4,460

See footnotes at end of table.

TABLE 11--Continued
LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY 1/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Slovenia: e/					
Primary	XX	XX	1,000	1,000	1,000
Secondary	XX	XX	3,000	3,000	3,000
Total	XX	XX	4,000	4,000	4,000
South Africa, Republic of:					
Secondary	31,200	32,200 r/	29,000	31,800 r/	31,800
Spain: e/					
Primary	60,000	110,000	62,000	62,400 r/	70,400
Secondary	50,000	59,000	58,000	62,400 r/	69,600
Total	110,000	169,000	120,000	125,000 r/	140,000
Sweden:					
Primary	47,500	49,200	54,100 r/	46,800	46,600
Secondary	22,100	38,800	37,100 r/	37,800 r/	36,000
Total	69,600	88,000	91,200 r/	84,600 r/	82,600
Switzerland: Secondary	5,700	5,000	6,400	6,000 r/	6,350 3/
Taiwan: Secondary e/	57,600	20,000	--	--	--
Thailand: Secondary	15,900	12,800	18,900	17,100 r/	18,000
Trinidad and Tobago: Secondary e/	1,800	1,800	1,800	1,700	1,600
Tunisia: e/					
Primary	2,200	750	913	900	900
Secondary	500	250	250	250	250
Total	2,700	1,000	1,160	1,150	1,150
Turkey: e/					
Primary	5,400	5,400	3,000 r/	3,000	3,000
Secondary	3,600	3,100	2,100 r/	2,000	2,100
Total	9,000	8,500	5,100 r/	5,000	5,100
U.S.S.R.: e/ 7/					
Primary	420,000	380,000	XX	XX	XX
Secondary	280,000	250,000	XX	XX	XX
Total	700,000	630,000	XX	XX	XX
Ukraine: Secondary e/	XX	XX	5,000	4,000	4,000
United Kingdom:					
Primary	156,000	164,000	199,000	210,000 r/	182,000 3/
Secondary	174,000	147,000	148,000	154,000 r/	161,000 3/
Total	330,000 r/	311,000	347,000	364,000 r/	343,000 3/
United States:					
Primary	404,000	346,000	305,000	335,000	351,000 3/
Secondary	922,000	885,000	916,000	893,000 r/	913,000 3/
Total	1,330,000	1,230,000	1,220,000	1,230,000 r/	1,260,000 3/
Venezuela: Secondary e/	14,000	15,000	15,000	14,000 r/	15,000
Yugoslavia: 8/					
Primary	82,000	70,000 e/	XX	XX	XX
Secondary e/	17,000	18,000	XX	XX	XX
Total e/	99,000	88,000	XX	XX	XX
Zambia: Primary 9/	3,670	2,640	3,030	2,000 r/	--
Total primary	3,090,000	3,080,000 r/	2,950,000 r/	3,050,000 r/	2,970,000
Total secondary	2,860,000 r/	2,690,000 r/	2,480,000 r/	2,400,000 r/	2,420,000
Grand total	5,950,000 r/	5,770,000 r/	5,430,000 r/	5,450,000 r/	5,380,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 6, 1995. Data included represent the total output of refined lead by each country, whether derived from ores and concentrates (primary) or scrap (secondary), and include the lead content of antimonial lead, but exclude, to the extent possible, simple remelting of scrap.

3/ Reported figure.

4/ Dissolved Dec. 31, 1992. All production in Czechoslovakia from 1990-92 came from the Czech Republic.

5/ May include primary.

6/ Includes products of imported concentrate.

7/ Dissolved in Dec. 1991.

8/ Dissolved in Apr. 1992.

9/ Data are for fiscal year beginning Apr. 1 of that stated. Smelter operation closed Mar. 1993. Production in 1993 includes secondary output and may all be simply remelt.

TABLE 12
PRODUCTION AND SHIPMENTS OF LEAD PIGMENTS 1/ 2/ AND OXIDES IN THE UNITED STATES

(Metric tons unless otherwise specified)

Product	1993				1994			
	Production		Shipments		Production		Shipments	
	Gross weight	Lead content	Quantity	Value 3/	Gross weight	Lead content	Quantity	Value 3/
White lead, dry	W	W	W	W	W	W	W	W
Litharge and red lead	74,200	68,800	70,400	$56,600,000	75,600	70,100	70,400	$56,100,000
Leady oxide	276,000 r/	262,000 r/	NA	NA	290,000	275,000	NA	NA
Total	350,000 r/	331,000 r/	NA	NA	366,000	346,000	NA	NA

r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Total."

1/ Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ At plant, exclusive of container.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF LEAD PIGMENTS AND COMPOUNDS, BY KIND 1/

Kind	Quantity (metric tons)	Value (thousands)
1993		
White lead carbonate	69	$116
Red and orange lead	57	186
Chrome yellow and molybdenum orange pigments and lead-zinc chromates	4,540	10,800
Litharge	18,600	9,280
Leady litharge	508	333
Glass frits (undifferentiated)	7,080	12,900
Total	30,900	33,600
1994		
White lead carbonate	121	209
Red and orange lead	84	189
Chrome yellow and molybdenum orange pigments and lead-zinc chromates	5,970	14,100
Litharge	19,700	12,600
Leady litharge	401	307
Glass frits (undifferentiated)	10,400	16,200
Total	36,700	43,600

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 14
U.S. EXPORTS OF LEAD, BY COUNTRY 1/

(Lead content unless otherwise specified)

Country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ore and concentrates:				
Belgium	14,300	$1,140	13,900	$3,410
Canada	6,120	3,540	10,800	4,100
Italy	16,400	2,630	--	--
Japan	4,380	206	2,880	707
Korea, Republic of	457	263	7,740	1,980
Mexico	38	12	3,130	934
Other	108 r/	47 r/	244	84
Total	41,800	7,840	38,700	11,200
Ash and residues:				
Belgium	1,400	368	13,600	6,460
Canada	249	913	6,810	4,530
Other	76 r/	45 r/	190	125
Total	1,730	1,330	20,600	11,100
Unwrought lead and lead alloys:				
Belgium	252	350	86	525
Canada	4,630	2,670	5,100	3,200
Chile	3,360	8,290	1,100	2,190
Indonesia	4,030	1,720	2,230	1,180
Israel	481	349	1,410	747
Japan	4,860	2,400	2,820	1,800
Korea, Republic of	18,700	8,660	23,400	12,100
Malaysia	1,660	766	1,230	624
Mexico	164	214	522	660
Taiwan	13,100	5,960	9,910	5,400
Other	201 r/	929 r/	427	1,130
Total	51,400	32,200	48,200	29,500
Wrought lead and lead alloys:				
Brazil	17	64	67	89
Canada	1,310	3,360	1,110	3,350
Costa Rica	97	211	108	240
France	9	486	49	280
Germany	189	223	265	138
Hong Kong	1,100	2,740	1,330	2,670
India	26	34	163	158
Japan	188	617	109	555
Korea, Republic of	974	934	160	558
Malaysia	235	573	41	269
Mexico	1,150	4,570	871	7,850
Netherlands	121	356	251	343
New Zealand	79	131	138	213
Saudi Arabia	12	39	115	305
Taiwan	729	2,030	82	290
United Kingdom	206	479	101	703
Other	703 r/	2,850 r/	385	1,330
Total	7,140	19,700	5,340	19,300
Scrap (gross weight):				
Bahamas, The	119	54	(2/)	27
Brazil	4,680	643	4,110	936
Canada	38,700	6,840	68,400	13,000
China	1,550	372	458	288
Germany	105	35	15	119
Hong Kong	656	323	49	19
India	970	237	941	156
Japan	520	511	127	321
Korea, Republic of	2,680	3,000	9,440	6,070
Mexico	2,030	1,010	903	1,140
United Kingdom	457	219	903	292
Other	1,770 r/	1,250 r/	2,750	2,150
Total	54,100	14,400	88,100	24,500

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 15
U.S. IMPORTS FOR CONSUMPTION OF LEAD, BY COUNTRY 1/

(Lead content unless otherwise specified)

Country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ore and concentrates: 2/				
Belgium	--	--	184	$57
Canada	--	--	163	40
Korea, Republic of	--	--	126	39
Mexico	464	$345	(3/)	3
Peru	19	2	--	--
Total	483	347	473	138
Base bullion:				
Canada	13	49	575	278
Other	5 r/	13 r/	2	7
Total	18	62	577	284
Pigs and bars:				
Australia	5,000	2,140	500	191
Belgium	303	346	704	1,470
Bulgaria	--	--	31	18
Canada	131,000	58,500	159,000	92,300
China	6	13	167	131
France	56	46	252	366
Germany	330	478	4,460	3,040
Korea, Republic of	59	42	2,000	1,020
Mexico	40,300	16,100	31,900	16,500
Morocco	--	--	300	187
Namibia	--	--	3,200	2,000
Peru	18,300	6,850	25,600	14,400
Russia	--	--	1,150	629
South Africa, Republic of	13	18	39	38
Sweden	--	--	799	477
United Arab Emirates	384	545	261	977
United Kingdom	30	28	10	28
Venezuela	--	--	332	178
Other	(4/)	(4/)	59	97
Total	196,000	85,100	231,000	134,000
Reclaimed scrap, including ash and residues: 5/				
Canada	58	29	128	39
Other	19 r/	11	16	40
Total	78 r/	39	144	80
Wrought lead, all forms, including wire and powders (gross weight):				
Canada	1,760	3,000	2,590	4,020
Chile	50	84	--	--
China	104	421	85	509
France	12	90	62	163
Germany	297	1,090	193	1,060
Hong Kong	196	530	170	463
India	(2/)	2	144	259
Italy	283	521	389	553
Japan	55	552	317	1,510
Mexico	1,600	1,290	1,490	1,460
Namibia	1,000	448	--	--
Peru	168	131	18	13
South Africa, Republic of	1,000	448	--	--
Taiwan	124	374	197	732
United Kingdom	169	644	99	746
Other	74 r/	662 r/	66	615
Total	6,890	10,300	5,820	12,100

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Also includes other lead-bearing materials containing greater than 5 troy ounces of gold per short ton, or greater than 100 troy ounces of total precious metals per short ton.

3/ Less than 1/2 unit.

4/ Revised to zero.

5/ Also includes other lead-bearing materials containing greater than 10% by weight of copper, lead, or zinc (any one).

Source: Bureau of the Census.

LIME

By M. Michael Miller

Lime is an important chemical with hundreds of chemical, industrial, and environmental uses in the United States. Its history probably dates back at least 4,000 to 6,000 years. The ancient Egyptians utilized lime as an ingredient in mortar and plaster. The Greeks, Romans, and Chinese utilized lime for construction, agriculture, bleaching, and tanning. Its uses began expanding with the advent of the industrial revolution, but it remained primarily a construction commodity until the rapid growth of the chemical process industries at the beginning of the 20th century. At the turn of the century, over 80% of lime consumed in the United States went for construction uses, but now over 90% of lime is consumed for chemical and industry uses.

Lime is a basic chemical that ranked fifth in total production in the United States in 1994. It is produced in 33 States and Puerto Rico, and its major uses are in steelmaking; pulp and paper manufacturing; construction; and the treatment of water, sewage, and smokestack emissions.

Total lime sold or used by domestic producers, excluding that from Puerto Rico, increased by about 600,000 tons (660,000 short tons) to 17.4 million tons (19.2 million short tons) in 1994. Production included the commercial sale or captive consumption of quicklime, hydrated lime, and dead-burned refractory dolomite. These products were valued at more than $1,020 million. Commercial sales increased by 600,000 tons (660,000 short tons) to a record high of 15.5 million tons (17.1 million short tons), while captive consumption was essentially unchanged at 1.88 million tons (2.07 million short tons). *(See table 1.)*

Production

The term "lime", as used throughout this chapter, refers primarily to six chemicals produced by the calcination of high-purity calcitic or dolomitic limestone followed by hydration where necessary. They are (1) quicklime, calcium oxide (CaO); (2) hydrated lime, calcium hydroxide [$Ca(OH)_2$]; (3) dolomitic quicklime ($CaO \cdot MgO$); two types of dolomitic hydrate, (4) type N [$Ca(OH)_2 \cdot MgO$] and (5) type S [$Ca(OH)_2 \cdot Mg(OH)_2$]; and (6) dead-burned dolomite. Nondolomitic quicklime and hydrated lime are also called high-calcium lime. Lime also can be produced from a variety of calcareous materials such as aragonite, chalk, coral, marble, and shell. Lime is also regenerated; that is, produced as a byproduct, by paper mills, carbide plants, and water treatment plants; however, regenerated lime is beyond the scope of this report.

Domestic production data for lime are developed by the U.S. Bureau of Mines from two separate, voluntary surveys of U.S. operations. The survey used to prepare this report is the annual "Lime" survey. Of the 114 operations to which the annual survey request was sent, 98 responded, representing 86% of the total sold or used by producers shown in table 2. Production for 12 nonrespondents was provided based on the monthly survey. Production for four nonrespondents was estimated using reported prior-year production figures.

In 1994, 64 companies produced lime. Leading producing companies, in descending order, were Chemical Lime Co., with two plants each in Alabama, Arizona, California, Nevada, and Texas and one each in Idaho and Utah; Dravo Lime Co., with two plants in Kentucky and one plant in Alabama; Mississippi Lime Co. in Missouri; Marblehead Lime Co., with two plants in Illinois and one each in Indiana and Michigan; Continental Lime Inc., with one plant each in Montana, Nevada, Utah, and Washington; Martin Marietta Magnesia Specialties in Ohio; APG Lime Co., with one plant each in Texas and Virginia; Wimpey Minerals PA, Inc., with two plants in Pennsylvania, U.S. Lime & Minerals, Inc., with one plant each in Arkansas, Pennsylvania, and Texas; and LTV Steel in Ohio. These 10 companies operated 32 plants and accounted for nearly 64% of total lime production.

Domestic lime plant capacity is based on 365 days minus the average number of days for maintenance times the average 24-hour capacity of quicklime production, including quicklime converted to hydrated lime, and reported in short tons per year. Specific plant capacity data were unavailable for all commercial lime plants. *(See tables 2 and 3.)*

The year was marked by numerous announcements of closures, restructuring, name changes, acquisitions, planned capacity increases, and new plant construction. Some of the most significant announcements came out of the two largest U.S. lime companies, Chemical Lime Co. and Dravo Lime Co.

The Chemical Lime group of companies was reorganized under a single company name, Chemical Lime Co. The company organized itself into an eastern division consisting of the former Allied Lime plants in Alabama and the Chemical Lime plants in Texas, and a western division consisting of the former Chemstar plants in Arizona, California, Idaho, Nevada, and Utah.[1]

Chemical Lime Co. announced plans to build a new lime plant near Ste. Genevieve, MO, containing two 1,100-ton-per-day (1,200-short-ton) Kennedy Van Saun (KVS) preheater rotary kilns. The construction of this plant was necessitated by the signing of a major long-term contract to supply Monongahela Power Company's Harrison Station near Shinnston, WV. The powerplant will require about 363,000 tons per year (400,000 short tons) of magnesium enhanced lime, which Chemical Lime markets as MAG-ON-DEMAND.[2]

Chemical Lime also announced plans to expand its production of liquid calcium hydroxide slurry. The company anticipates increased demand for neutralization products because of the short supply and volatility of caustic soda prices. Expansions were completed in Florida and in Texas, and the California expansion was scheduled for early 1994.[3]

Dravo Lime Co. reached a renewal agreement to supply about 159,000 tons per year (175,000 short tons) of lime for 10 years to Monongahela Power's Pleasants Station in West Virginia.[4] It also reached a renewal agreement to supply about 408,000 tons per year (450,000 short tons) for 13 years to Pennsylvania Power Company's Bruce Mansfield Station in Pennsylvania.[5] These renewal agreements are in addition to the 15-year contract to supply about 408,000 tons per year (450,000 short tons) to Ohio Power Company's James M. Gavin Station in southeastern Ohio.[6] As a result of these major flue gas desulfurization contracts, Dravo Lime Co. announced plans to expand capacity at its Black River Division at Carntown, KY. The planned expansion called for the installation of two 1000-ton-per-day (1,100-short-ton) KVS preheater rotary kilns; two lime storage silos; a barge loadout system; three coal storage silos; and a limestone processing, storage, and reclaim system. Computerized process control is also being installed for all surface operations.[7]

Additional industry changes were reported by Global Stone Corp., Marblehead Lime Co., Marine Magnesium Co., and Scottish Heritable, Inc. Global Stone Corp. of Canada purchased Chemstone Corp., Strasburg, VA, a commercial producer of quicklime, hydrate, chemical grade limestone, and construction aggregates.[8] Global Stone also signed an agreement to lease for a period of 10 years the assets of Detroit Lime Co. from Edward C. Levy Co. The agreement includes an option to purchase the assets, which takes effect after Dec. 31, 1999.[9] Calcitherm Nederland N.V. of the Netherlands finalized the purchase of Marblehead Lime Co. from General Dynamics Corp. in early 1994.[10] Marine Magnesium Co. of South San Francisco, CA, a captive producer of dolomitic lime, sold its trademarks, tradenames, rights, and technology for the manufacture of magnesium chemicals to Morton International, Inc. All manufacturing was transferred to Morton's Michigan facilities and the South San Francisco facility was scheduled for demolition.[11] Scottish Heritable, Inc.; parent company of Arkansas Lime, Corson Lime, and Texas Lime; changed its name to United States Lime & Minerals, Inc. The former name was associated with the company's previous majority stockholder.[12]

Several companies announced capacity increases. Germany Valley Limestone Co., Riverton, WV, announced plans to install a 450-ton-per-day (500-short-ton) Kennedy Van Saun (KVS) preheater rotary kiln, due to come on line the last quarter of 1995.[13] Continental Lime Inc. installed hydrators at its plants at Townsend, MT, and Wendhover, NV, and also announced plans to add a 635-ton-per-day (700-short-ton) preheater rotary at Wendhover, NV.[14] Tenn Luttrell Co., Luttrell, TN, which had been purchased by Global Stone Corp. in October 1993, finished permitting and began construction of a 300-ton-per-day (330-short-ton) vertical kiln.[15] *(See table 4.)*

Consumption and Uses

Lime was consumed in every State. The breakdown of consumption by major end uses was as follows: 64% for chemical and industrial uses, 26% for environmental uses, 8% for construction uses, and 2% for refractory dolomite. Captive lime was used mainly in sugar refining and in the production of steel in basic oxygen furnaces.

In steel refining, quicklime was used as a flux to remove impurities such as phosphorus, silica, and sulfur. Dolomitic lime was often substituted for a fraction of the high-calcium lime to extend refractory life. Dead-burned dolomite, also called refractory lime, was used as a component in tar-bonded refractory brick used in basic oxygen furnaces. Lime consumption by the steel industry increased by nearly 4% to 5.3 million tons (5.8 million short tons) and accounted for about 31% of all lime consumed in the United States.

In nonferrous metallurgy, lime was used in the beneficiation of copper ores to neutralize the acidic effects of pyrite and other iron sulfides and maintain the proper pH in the flotation process. It was used to process alumina and magnesia, to extract uranium from gold slimes, and in the recovery of nickel by precipitation. It was used in gold and silver recovery operations to control the pH of the sodium cyanide solution used to leach the gold and silver from the ore. Such leaching processes are called dump leaching when large pieces of ore are involved, heap leaching when small pieces of ore are involved, and carbon-in-pulp cyanidation when the ore is leached in agitated tanks. Dump and heap leaching involve crushing the ore, mixing it with lime for pH control and agglomeration, and stacking the ore in heaps for treatment with cyanide solution. Lime is used to maintain the pH of the cyanide solution at a pH level between 10 and 11 to maximize precious-metals recovery and to prevent the creation of hydrogen cyanide gas. In the environmental sector, lime was used in the softening and clarification of municipal potable water. In sewage treatment, lime was used to control pH in the sludge digester, which removes dissolved and suspended solids that contain phosphates and nitrogen compounds. It also aided clarification and killing of bacteria. Lime was used to neutralize acid mine and industrial discharges. In FGD systems serving utility and industrial plants, lime was used to react with sulfur oxides in the flue gas. Lime was used to stabilize sludges from sewage and desulfurization plants before disposal.

The paper industry used lime as a coagulant aid in the clarification of plant process water. It was used, generally in conjunction with soda ash, for softening plant process water. This is a precipitation process to remove bivalent soluble calcium and magnesium cations (and to a lesser extent manganese, ferrous iron, zinc, and strontium), which contribute to the hardness of water. This process also reduces carbonate alkalinity and dissolved solids content.

In the basic Kraft pulping process, wood chips and an aqueous solution (called liquor) of sodium hydroxide and sodium sulfide are heated in a digester. The cooked wood chips (pulp) are discharged under pressure along with the spent liquor. The pulp is screened, washed, and sent directly to the paper machine or for bleaching. Lime is sometimes used to produce calcium hypochlorite bleach for bleaching the paper pulp. The spent liquor is processed through a recovery furnace where dissolved organics are burned to recover waste heat and where sodium sulfide and sodium carbonate are recovered. The recovered sodium sulfide and sodium carbonate are diluted with water and then treated with slaked lime to recausticize the sodium carbonate into sodium hydroxide (caustic soda) for reuse.

Lime was used to make precipitated calcium carbonate (PCC), a specialty pigment used in premium-quality coated and uncoated papers. The most common PCC production process used in the United States is the carbonation process. Carbon dioxide is bubbled through milk-of-lime to form a precipitate of calcium carbonate and water. The reaction conditions determine the size and shape of the resulting PCC crystals.

Specialty Minerals Inc. (SMI) and Continental Lime Inc. entered into an agreement where SMI would distribute and resell precipitated calcium carbonate produced by Continental at its facility in Tacoma, WA. This agreement eliminates the need for SMI to build a new mill in the Pacific Northwest and provides Continental with SMI's greater experience in servicing existing customers and developing new customers. Continental has also agreed to increase precipitated calcium carbonate production capacity, if SMI can generate new sales. SMI also announced plans to expand production capacity at its merchant precipitated calcium carbonate plant in Adams, MA.[16]

The chemical industry used lime in the manufacture of alkalies. Quicklime was combined with coke to produce calcium carbide, which was used to make acetylene and calcium cyanide. Lime was used to make calcium hypochlorite, citric acid, petrochemicals, and other chemicals.

In sugar refining, milk of lime, a suspension of hydrated lime in water, was used to raise the pH of the product stream, precipitating colloidal impurities. The lime itself was then removed by reaction with carbon dioxide to precipitate calcium carbonate. The carbon dioxide was obtained as a byproduct of lime production.

Dolomitic quicklime was used as a flux in the manufacture of glass. Quicklime was used to make calcium silicate building products such as sand-lime brick; hydrated lime was used to produce silica refractory brick.

In construction, lime was used for soil stabilization to upgrade clay soils into satisfactory base and subbase materials. Common applications included the construction of roads, airfields, building foundations, earthen dams, and parking areas. Hydrated lime was used with fly ash to make a base material, in asphalt mixes to act as an antistripping agent, and in plaster, stucco, and mortar to improve durability. *(See table 5.)*

Prices

The average value of lime sold or used by producers, as reported to the U.S. Bureau of Mines on an f.o.b. plant basis, increased in 1994 to $58.73 per ton ($53.28 per short ton). Average values per ton were $58.20 ($52.81 per short ton) for chemical and industrial lime, $56.64 ($51.39 per short ton) for environmental lime, $64.11 ($58.16 per short ton) for construction lime, $76.79 ($69.66 per short ton) for agricultural lime, and $83.16 ($75.44 per short ton) for refractory dolomite.

The average value of quicklime sold increased to $56.43 per ton ($51.19 per short ton). Average values per ton were $57.02 ($51.73 per short ton) for chemical and industrial lime, $53.91 ($48.91 per short ton) for environmental lime, $56.77 ($51.50 per short ton) for construction lime, and $80.43 ($72.97 per short ton) for refractory dead-burned dolomite. Almost no quicklime was sold as aglime.

The average value of hydrated lime sold decreased to $67.71 per ton ($61.43 per short ton). Average values per ton were $64.13 ($58.18 per short ton) for chemical lime, $69.72 (63.25 per short ton) for environmental lime, $67.81($61.51 per short ton) for construction lime, and $76.18 ($69.11 per short ton) for agricultural lime.

Foreign Trade

According to the Bureau of the Census, exports of lime increased by 7% to 74,000 tons (82,000 short tons). Imports of lime were essentially unchanged at 204,000 tons (225,000 short tons). Most U.S. trade was with Canada and Mexico, which together accounted for nearly 100% of the U.S. exports and imports of lime. Canada was the major trading partner, receiving 85% of U.S. exports and shipping 95% of U.S. imports. *(See table 1.)*

Current Research

The Zedmark Division of Minteq International Inc. has designed and field tested a new kiln lining for rotary kilns. The new lining, which operates as an internal heat exchanger, converts the internal surface of the kiln from circular to multi-sided. This overcomes the problems caused by the kiln load sliding on the refractory. The polygonal shape allows the lifting and tumbling of the load over itself resulting in more efficient mixing and improved heat transfer. The lining is more mechanically and thermally stable and can be used throughout the kiln, including in the burn zone. Other benefits of the new lining include lower maintenance costs than traditional heat linings, lower weight than trefoil linings, and lower dust generation. The new design is quicker and less expensive to install than tumblers, lifters or trefoils.[17]

Current pyrometallurgical copper production methods result in large amounts of sulfur dioxide, which result in the need for expensive pollution control equipment. Research has been conducted to further the understanding of the lime-concentrate roasting process for recovery of copper-bearing sulfides. Such a process, utilizing hydrated lime, captures sulfur as calcium sulfate. As an extension to the research done by R. W. Bartlett and H. H. Haung in the 1970's, researchers in the United Kingdom and Chile analyzed optimum roasting conditions; the effect of the sulfide:lime ratio, air flow rate, pellet size, and porosity on reaction kinetics; and mechanisms of roasting reactions.[18]

Outlook

Lime has dozens of end uses in the chemical, industrial, and construction industries. Steelmaking is still the largest single end use for lime. The steel industry is adding capacity in the form of 10 new minimills, which will add 9 to 18 million tons per year (10 to 20 million short tons) of new flat-rolled steel capacity. Minimills do not consume as much lime per ton of steel as a large integrated steel producer, but the new mills would require an estimated 370,000 to 740,000 tons (410,000 to 820,000 short tons) of lime per year. This demand would be split between high-calcium and dolomitic lime, approximately 65% and 35%, respectively.

The FGD market is showing the growth expected due to the requirements of Phase I compliance with the Clean Air Act Amendments. The lime industry announced plans to install about 1.8 million tons (2 million short tons) of new capacity in 1995, most of which is intended to supply increased demand for FGD lime. Three midwestern powerplants have begun consuming lime in recently installed scrubbers. Over the course of a year, these plants alone will consume about 725,000 to 815,000 tons (800,000 to

900,000 short tons) per year. Longer-term increases could materialize from the use of lime in dry scrubbers used with small utility boilers (less than 25 Mw), which will be regulated in Phase II of the Clean Air Act Amendments.

Additionally, as a result of the increasing regulation of sulfur dioxide, nitrogen oxides, heavy metals, and fly ash from combustion units, an integrated process to treat flue gases has been developed as an alternative to traditional systems that operate a separate system for each pollutant. A three-stage lime system designed to capture sulfur dioxide and fly ash simultaneously and incorporating a selective catalytic reduction unit to recover nitrogen oxides shows cost and operational advantages over traditional systems. These operational and cost advantages may result in switch from limestone systems to lime systems as utility and industrial operators become more familiar with the potential advantages of the integrated lime system.[19]

The Environmental Protection Agency has proposed new rules regulating emissions of dioxins, heavy metals, and air-borne toxins from smaller municipal incinerators. If the new rules are passed, they would affect about 180 existing incinerators that would probably have to install new pollution control equipment. Current control equipment involves dry-lime scrubbing coupled with bag houses or electrostatic precipitators. Passage of these rules would provide a boost to the incinerator gas scrubbing market in the late 1990's.

Consumption of lime for FGD will likely top 3 million tons (3.3 million short tons) in the next 2 to 3 years, and increase even more when Phase II of the Clean Air Act Amendments goes into effect January 1, 2000.

Other environmental markets as a whole were relatively stable, with a slight increase in the sewage treatment market, which probably reflects the continued growth in the sewage sludge stabilization market. Despite occasional variations in yearly consumption patterns, the individual environmental markets should remain strong, with the greatest potential for growth in sewage sludge stabilization.

Despite downward revisions to the 1993 soil stabilization numbers and the apparent decrease in 1994, soil stabilization will remain a major market, particularly in Texas. The use of lime in asphalt paving should continue to grow.

Lime's traditional pulp and paper market increased in 1994 and paper industry analysts forecast that pulp, paper, and paperboard production will grow faster in 1995 than the overall economy.

The PCC market also increased in 1994 and should continue to show growth as PCC, especially as industry leader Specialty Minerals, Inc., attempts to expand the market share of PCC in the paper coating pigment market.

The three chemical caustic soda plants constructed in recent years all reopened in 1994, as a result of tight caustic soda supplies and higher prices. When operating, one plant purchases 100% of required lime and the other two regenerate lime needing only to purchase make-up lime. Caustic soda prices increased dramatically in 1994, which made reopening the chemical caustic plants economically feasible. Prices stabilized in the first half of 1995 with contract prices for the remainder of 1995 reported at $235 per ton. Caustic supplies are expected to become tight in 1996, which would put upward pressure on prices. As long as caustic supplies are tight and prices remain at their current level or go higher, chemical caustic will be economically competitive. The chemical caustic industry remains a regional market for lime, albeit a cyclic market that depends entirely on the price of caustic soda.

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TABLE 1
SALIENT LIME STATISTICS 1/

(Thousand metric tons unless otherwise specified) 2/

		1990	1991	1992	1993	1994
United States: 3/						
Number of plants		113	112	112	112	108
Sold or used by producers:						
Quicklime		13,400	13,200	13,700	14,200 r/	14,800
Hydrated lime		2,100	2,170	2,230	2,250 r/	2,290
Dead-burned dolomite		342	308	302	315	300
Total		15,800	15,700	16,200	16,800 r/	17,400
Value 4/	thousands	$902,000	$890,000	$950,000	$965,000 r/	$1,020,000
Average value per ton		$57.09 r/	$56.69 r/	$58.64 r/	$57.44 r/	$58.62
Lime sold		14,000	13,800	14,300	14,900 r/	15,500
Lime used		1,820	1,820	1,890	1,870 r/	1,880
Exports 5/		49	47	59	69	74
Value	thousands	$6,150	$6,060	$7,540	$7,830	$7,800
Imports for consumption 5/		157	158	193	201	204
Value	thousands	$10,400	$11,100	$15,000	$13,300	$13,100
Consumption, apparent 6/		15,900	15,800	16,300	16,900 r/	17,530
World: Production		136,000	132,000	127,000 r/	125,000 r/	118,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, may not add to totals shown.

2/ To convert metric tons to short tons multiply metric tons by 1.10231.

3/ Excludes regenerated lime. Excludes Puerto Rico.

4/ Selling value, f.o.b. plant, excluding cost of containers.

5/ Bureau of the Census.

6/ Calculated by sold or used plus imports minus exports.

TABLE 2
LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/ 2/

	1993					1994				
State	Plants	Hydrated (thousand metric tons)	Quicklime (thousand metric tons)	Total (thousand metric tons)	Value (thousands)	Plants	Hydrated (thousand metric tons)	Quicklime (thousand metric tons)	Total (thousand metric tons)	Value (thousands)
Alabama	4	178	1,450	1,630	$89,500	4	184	1,470	1,660	$88,300
Arizona, Nevada, Utah	8	199	1,410	1,610	72,400	8	243	1,570	1,810	114,000
California	9	22	171	193	14,800	7	26	178	203	16,900
Colorado, Montana, Wyoming	10	--	369	369	24,200	10	--	335	335	20,900
Idaho, Oregon, Washington	8	17	547	565	40,900	8	25	597	622	44,600
Illinois, Indiana, Missouri	8	455	2,730	3,190	175,000	8	464	2,910	3,380	184,000
Iowa, Nebraska, South Dakota	5	W	W	235	14,400	5	W	W	242	13,700
Kentucky, Tennessee, West Virginia	5	129	1,730	1,850	105,000	5	132	1,800	1,930	106,000
Michigan	8	25	592 r/	617 r/	32,100 r/	9	26	611	637	33,000
North Dakota	3	--	112 r/	112 r/	4,800 r/	3	--	108	108	6,590
Ohio	9	W	W	1,700	101,000	9	W	W	1,850	113,000
Pennsylvania	9	286	1,250	1,540	95,400	8	263	1,330	1,590	95,500
Puerto Rico	1	27	--	27	3,650	1	23	(3/)	23	2,970
Texas	7	522 r/	850 r/	1,370 r/	86,400 r/	6	471	740	1,210	76,200
Virginia	5	117	639	756	40,000	5	121	621	742	40,200
Wisconsin	4	116	395	511	30,900	4	124	383	507	30,300
Other 4/	9	181	2,260 r/	507 r/	35,200 r/	9	213	2,430	548	35,300
Total	112	2,270 r/	14,500 r/	16,800 r/	965,000 r/	109	2,310	15,100	17,400	1,020,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Excludes regenerated lime. Includes Puerto Rico.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three siginificant digits; may not add to totals shown.

3/ Less than 1/2 unit.

4/ Includes Arkansas, Louisiana, Massachusetts, Minnesota, Oklahoma, and data indicated by the symbol W.

TABLE 3
LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, 1/ BY RANGE OF PRODUCTION 2/

Range of production	1993 Plants	1993 Quantity 3/ (thousand metric tons)	1993 Percent of total	1994 Plants	1994 Quantity 3/ (thousand metric tons)	1994 Percent of total
Less than 10,000 tons	8	57 r/	(4/)	9	52	(4/)
10,000 to 25,000 tons	19	288 r/	2	16	238	1
25,000 to 50,000 tons	13	385 r/	2	13	370	2
50,000 to 100,000 tons	23	1,670 r/	10	15	1,000	6
100,000 to 200,000 tons	17	2,140	13	24	3,070	18
200,000 to 400,000 tons	20	4,980 r/	32	21	5,220	31
More than 400,000 tons	12	7,260 r/	41	11	7,450	42
Total	112	16,800 r/	100	109	17,400	100

r/ Revised.

1/ Excludes regenerated lime. Includes Puerto Rico.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ To convert metric tons to short tons multiply metric tons by 1.10231.

4/ Less than 1/2 unit.

TABLE 4
DESTINATION OF SHIPMENTS OF LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/ 2/

(Thousand metric tons) 3/

State	1993			1994		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	661	47	708	619	53	673
Alaska	5	1	6	7	1	8
Arizona	321	47	368	488	59	547
Arkansas	124	25	149	180	25	205
California	343	67	410	402	83	485
Colorado	156	32	189	73	38	111
Connecticut	22	2	24	21	6	27
Delaware	17	2	19	54	4	58
District of Columbia	8	8	16	13	13	26
Florida	400	22	422	390	24	414
Georgia	216	86	302	233	79	312
Hawaii	--	(4/)	(4/)	(4/)	(4/)	(4/)
Idaho	162	2	163	210	2	213
Illinois	504	161	664	448	162	610
Indiana	1,400 r/	31	1,430 r/	1,550	34	1,590
Iowa	56	25	81	65	25	90
Kansas	83 r/	21	104 r/	81	25	106
Kentucky	371 r/	36 r/	407 r/	373	37	411
Louisiana	221 r/	86	306 r/	252	91	343
Maine	4	(4/)	4	3	(4/)	3
Maryland	124	17	141	104	17	121
Massachusetts	143	12	155	147	13	159
Michigan	918 r/	32	950 r/	940	30	969
Minnesota	302 r/	17	319 r/	271	18	289
Mississippi	187	16	204	194	22	216
Missouri	166	58	223	164	62	226
Montana	122	9	131	141	11	152
Nebraska	54	10	65	58	9	67
Nevada	415	36	451	468	46	515
New Hampshire	2	(4/)	2	2	(4/)	2
New Jersey	115	20	135	146	22	168
New Mexico	130	42 r/	172 r/	43	31	74
New York	87	26	113	83	31	114
North Carolina	202	43	245	197	44	241
North Dakota	261 r/	3	264 r/	225	3	228
Ohio	1,700 r/	137 r/	1,840 r/	1,830	161	1,990
Oklahoma	120	9	129	138	13	151
Oregon	130	18	148	106	27	133
Pennsylvania	1,540	203	1,740	1,630	173	1,800
Rhode Island	8	1	9	2	1	3
South Carolina	191	48	239	223	45	268
South Dakota	19	1	20	20	3	22
Tennessee	193	48	241	203	52	256
Texas	836 r/	526 r/	1,360 r/	716	468	1,180
Utah	263	21	284	288	26	314
Virginia	205	56	261	209	43	252
Washington	231	12	243	272	17	289
West Virginia	421	52	473	484	62	546
Wisconsin	136	43	179	136	40	176
Wyoming	124	15	140	97	20	117
Total	14,400 r/	2,230 r/	16,700 r/	14,900	2,270	17,300
Puerto Rico	--	21	21	8	18	18
Canada	55	16	71	62	17	79
Other 5/	25	8	32	12	6	26
Total	80	45	124	82	41	123
Grand total	14,500 r/	2,280 r/	16,800 r/	15,000	2,310	17,400

r/ Revised.

1/ Excludes regenerated lime.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ To convert metric tons to short tons multiply metric tons by 1.10231.

4/ Less than 1/2 unit.

5/ Includes other countries and U.S. possessions.

TABLE 5
LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/ 2/

(Thousand metric tons and thousand dollars) 3/

Use	1993				1994			
	Sold	Used	Total	Value	Sold	Used	Total	Value
Agriculture	19	--	19	1,430	19	--	19	1,440
Chemical and industrial:								
Alkalies	W	W	129	6,200	W	W	115	5,790
Aluminum and bauxite	155 r/	--	155 r/	8,980 r/	142	--	142	8,060
Copper ore concentration	W	W	W	18,400 r/	W	W	W	25,200
Food products, animal or human	23 r/	--	23 r/	1,790 r/	17	--	17	1,190
Glass	109	--	109	6,650	114	--	114	7,250
Oil well drilling	12 r/	--	12 r/	751 r/	12	--	12	819
Oil and grease	46	--	46	4,620	36	--	36	4,420
Ore concentration, other	366 r/	--	366 r/	21,100 r/	611	--	611	36,000
Paper and pulp	W	W	1,030 r/	60,300 r/	W	W	1,160	69,300
Petrochemicals	39 r/	--	39 r/	2,840 r/	67	--	67	5,350
Precipitated calcium carbonate	473	99 r/	572 r/	30,300 r/	540	114	654	35,200
Steel:								
Basic oxygen furnaces	W	W	3,560 r/	193,000 r/	W	W	3,850	207,000
Electric arc furnaces	1,140 r/	--	1,140 r/	58,200 r/	1,050	--	1,050	60,600
Argon oxygen decarburization	96	--	96	5,240	106	--	106	5,960
Ladle desulfurization, iron or steel	116	--	116	6,380	83	--	83	4,640
Other chemical and industrial 4/	191 r/	--	191 r/	10,900 r/	227	--	227	12,800
Total steel:	1,540 r/	W	5,110 r/	274,000 r/	1,470	W	5,310	291,000
Sugar refining	32 r/	707 r/	738 r/	50,000 r/	32	691	723	45,800
Tanning	21	--	21	1,480	15	--	15	1,050
Other 4/	6,230 r/	883 r/	2,390 r/	115,000 r/	6,410	921	2,210	114,000
Total	9,050 r/	1,690 r/	10,700 r/	603,000 r/	9,470	1,730	11,200	651,000
Construction:								
Asphalt paving	126 r/	--	126 r/	7,370 r/	238	--	238	13,000
Finishing lime	41 r/	--	41 r/	3,080 r/	38	--	38	2,970
Mason's lime	(5/)	(5/)	164	11,200	(5/)	(5/)	168	11,100
Soil stabilization	973 r/	--	973 r/	60,300 r/	784	--	784	44,700
Other	184 r/	--	184 r/	12,300 r/	188	--	188	19,100
Total	(5/)	(5/)	1,490 r/	94,300 r/	(5/)	(5/)	1,420	90,800
Environmental:								
Acid water, mine or plant	364 r/	2	365 r/	22,500 r/	409	3	412	24,800
Flue gas sulfur removal	1,780 r/	--	1,780 r/	99,700 r/	1,960	--	1,960	104,000
Industrial solid waste treatment	34	--	34	1,960	53	--	53	2,910
Industrial wastewater treatment	39	--	39	2,320	40	--	40	2,440
Scrubber sludge solidification	53	--	53	2,990	53	--	53	2,980
Sewage treatment	462 r/	2	464 r/	28,800 r/	427	--	427	27,100
Water purification	1,060 r/	--	1,060 r/	63,300 r/	1,160	--	1,160	67,600
Other	418 r/	(6/)	418 r/	23,600 r/	373	--	373	21,600
Total	4,210 r/	2	4,210 r/	245,000 r/	4,470	3	4,480	254,000
Refractory lime (dead-burned dolomite)	(5/)	(5/)	315	26,200	(5/)	(5/)	300	25,000
Grand total	14,900 r/	1,870 r/	16,800 r/	970,000 r/	15,500	1,880	17,400	1,020,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Other Chemical and Industrial."

1/ Excludes regenerated lime. Includes Puerto Rico.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ To convert metric tons to short tons multiply metric tons by 1.10231.

4/ Includes briquetting, brokers, calcium carbide, chrome, citric acid, commerical hydrators, desiccants, ferroalloys, fiberglass, glue, insecticides, magnesia from seawater or brine, magnesium metal, metallurgy, pelletizing, pharmaceuticals, rubber, silica brick, soap.

5/ Withheld to avoid disclosing company proprietary data; included in "Grand total."

6/ Revised to zero.

TABLE 6

QUICKLIME AND HYDRATED LIME, INCLUDING DEAD-BURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Algeria (hydraulic)	32	61	62 e/	62 e/	62
Australia e/	1,500	1,500	1,500	1,500	1,500
Austria	1,640	1,600 e/	1,720	1,810 r/	1,850 4/
Belgium	2,080	2,020	1,870	1,750 e/	1,750
Belize e/	1	1	1	1	1
Bosnia Herzegovina e/	XX	XX	50	50	50
Botswana	(5/)	(5/)	– r/	– r/	–
Brazil e/	5,700	5,700	5,700	5,700	5,700
Bulgaria	1,560	1,030	1,000 e/	1,000 e/	1,000
Burundi	(5/)	(5/)	(5/)	(5/) e/	150
Canada	2,340	2,380	2,380 r/	2,380 r/	2,390
Chile (hydraulic) e/	1,300	1,200	1,300	1,300	1,250
China e/	17,000	18,500	19,000	19,500	19,500
Colombia e/	1,300	1,300	671	439 r/	450
Congo e/	(5/)	(5/)	(5/)	(5/)	(5/)
Costa Rica e/	13	9 4/	9	10	10
Croatia e/	XX	XX	200	200	180
Cuba e/	180	180	160	180	170
Cyprus (hydrated)	7	7	6	6 e/	6
Czech Republic	XX	XX	XX	2,500 e/	2,500
Czechoslovakia 6/	3,120	3,230	3,000 e/	XX	XX
Denmark (sales)	156 r/	114 r/	128 r/	124 r/	125
Dominican Republic e/	4	–	–	–	–
Egypt e/	68	749 4/	749	749	749
Ethiopia	(5/)	(5/)	(5/) e/	(5/) e/	(5/)
Finland e/	225	225	241 4/	250	315 4/
France e/	3,000	3,000	3,000	3,000	2,500
Germany:					
Eastern states	3,000 e/	XX	XX	XX	XX
Western states	6,890	XX	XX	XX	XX
Total	9,890 e/	7,530	7,540	7,480 r/	7,500
Guadeloupe e/	5	5	5	5	5
Guatemala e/	75	72	70	70	70
Hungary	831	571	446	300 e/	340
India e/	800	820	850	860	860
Iran e/	650	650	650	650	650
Ireland	112	110	110	100 e/	100
Israel	230	208	208 e/	208 e/	210
Italy e/ 7/	3,850	3,800	3,600	3,600 e/	3,500
Jamaica e/	90	95	179 4/	151 r/	170 4/
Japan (quicklime only)	8,980	9,040	8,050	7,960 r/	7,710 4/
Jordan	5	5	7	7 e/	7
Kenya	14	12	12 e/	12 e/	12
Korea, Republic of e/	230	240	240	250	250
Kuwait	50	5	5 e/	35 e/	40
Lebanon e/	10	10	15	15	15
Libya e/	260	260	260	260	260
Macedonia e/	XX	XX	20	20	20
Malawi e/	4 4/	4	4	4	4
Martinique e/	5	5	5	5	5
Mauritius e/	7	7	7	7	7
Mexico e/	6,000	6,500	6,500	6,500	6,500
Mongolia e/	103	76	50	55	55
New Zealand e/	100	90	100	100	100
Nicaragua	1	2	2	2 e/	2
Norway e/	100	100	100	100	100
Panama e/	3	1 3/	2	2	2
Paraguay e/	100	100	100	100	100
Peru e/	13	14	14	14	14

See footnotes at end of table.

TABLE 6--Continued

QUICKLIME AND HYDRATED LIME, INCLUDING DEADBURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Philippines	12	7	10 e/	10 e/	10
Poland	3,200	2,410	2,530	2,500 e/	2,500
Portugal e/	200	200	200	200	200
Romania e/	3,030 4/	3,000	3,000	3,000	3,000
Saudi Arabia e/	12	12	12	12	12
Serbia and Montenegro	XX	XX	565	500 e/	500
Slovakia 6/	XX	XX	XX	1,070 e/	1,000
Slovenia e/	XX	XX	250	250	250
South Africa, Republic of (sales)	1,830	1,770	1,740	1,600	1,600
Spain e/	1,200	1,200	1,200	1,200	1,000
Sweden	603	506	460 r/	500 e/	500
Switzerland e/	26 4/	40	30	40	40
Taiwan	554	614	670	650 e/	650
Tanzania (calcined and hydrated)	1	1 e/	2	1 e/	1
Tunisia e/	650	650	600	600	600
Turkey 8/	1,410	1,580	1,580	1,700 e/	1,800
Uganda	2 e/	2 e/	2	2	2
U.S.S.R. e/ 9/	28,000	26,000	23,000 10/	20,000 10/	16,000 10/
United Arab Emirates e/	45	45	45	45	45
United Kingdom e/	2,800	2,800	2,500	2,500	2,500
United States, including Puerto Rico (sold or used by producers)	15,900	15,700	16,200	16,800 r/	17,400 4/
Uruguay e/	12	12	12	12	12
Yugoslavia 11/	2,120	1,600	XX	XX	XX
Zaire	92	83	65	50 e/	40
Zambia	214	184	212	200 e/	200
Total	136,000	132,000	127,000 r/	125,000 r/	118,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 27, 1995.

3/ Lime is produced in many other countries besides those listed. Argentina, Iraq, Pakistan, and Syria are among the more important countries for which official data are not available. Venezuela does not report production of lime, which is thought to be produced in very small amounts on individual farms. Previous estimates of lime production in Venezuela have lacked any basis, and will not be reported in the future.

4/ Reported figure.

5/ Less than 1/2 unit.

6/ Dissolved Dec. 31, 1992.

7/ Includes hydraulic lime.

8/ Data are lime produced for steel production and do not include the widespread artisanal production of lime for cement whitewash and sanitation purposes.

9/ Dissolved in Dec. 1991.

10/ Total production of the former U.S.S.R.. Production data for the 15 new countries are not yet reported separately.

11/ Dissolved in Apr. 1992.

LITHIUM

By Joyce A. Ober

The United States has been the largest producer and consumer of lithium and the two U.S. companies have been the leading lithium carbonate producers in the world for many years. Chile has become an increasingly important player in the lithium industry, and with the expected development of a second lithium operation in that country, it may become the world lithium leader by the end of this century.

Because lithium is electrochemically reactive and has other unique properties, there are many commercial lithium products. Producers sold lithium as mineral concentrate, brine, compound, or metal depending on the end use. Most lithium compounds were consumed in the production of ceramics, glass, and primary aluminum.

Legislation and Government Programs

During 1994, the Department of Energy (DOE) negotiated to sell portions of its 36 million kilogram stock of lithium hydroxide monohydrate. No sales were made. DOE had planned to offer the lithium hydroxide in 1989, but delayed the disposal until an environmental impact study was complete. Since that time, sales were made in 1993 only.

The stocks were excess from a weapons program that used the lithium to make tritium, a hydrogen isotope necessary for nuclear fission reactions. The stockpile originally contained about 42,000 metric tons of material, from which about 75% of the lithium 6 isotope had been removed. This material possibly contained 8 to 9 parts per million of mercury, which could present an environmental hazard.

Production

The U.S. Bureau of Mines collects domestic production data for lithium from a voluntary survey of U.S. operations. The two U.S. companies responded to the survey, representing 100% of total production. Production and stock data were withheld from publication to avoid disclosing company proprietary data. *(See table 1.)*

Cyprus Foote Mineral Co. produced lithium carbonate from its brine deposit in Silver Peak, NV. In addition to its Nevada operation, Cyprus Foote, a subsidiary of Cyprus Amax Minerals Co. and the world's largest lithium producer, owned a spodumene mine and lithium carbonate plant that have been inactive since 1991 in Kings Mountain, NC. The lithium carbonate plant was dismantled in 1994. Cyprus Foote moved most of its administration, research, and lithium metal processing facilities to Kings Mountain. A new lithium hydroxide production facility was under construction at Silver Peak; upon completion of the new plant, Cyprus Foote's lithium hydroxide plant in Sunbright, VA, will be closed. A project to increase the production capacity by 50% at the company's New Johnsonville, TN, butyllithium plant was completed during the year. Cyprus Foote owned a large lithium operation in Chile.[1]

FMC Corp., Lithium Div., mined spodumene, a lithium ore, from pegmatite dikes near Bessemer City, NC, and produced lithium carbonate and a full range of downstream compounds, including lithium metal and some organic lithium compounds, at a chemical plant near the mine. The company also operated a butyllithium plant in Bayport, TX.

Spodumene is the most common lithium ore, but petalite and lepidolite are other types of lithium ores that are mined in different parts of the world. These three types of ore are beneficiated to produce lithium ore concentrates that can be consumed directly in certain applications. Spodumene concentrates and brines are converted to lithium carbonate and then other compounds for consumption in other end uses.

Lithium carbonate is the most important lithium compound produced from brine and ore deposits. Spodumene was a major raw material for the production of lithium carbonate in North Carolina, and small amounts of spodumene concentrate were produced for sale. Extracting lithium from spodumene entails an energy-intensive chemical recovery process.

After mining, spodumene is crushed and undergoes a flotation beneficiation process to produce concentrate. Concentrate is heated to 1,075° C to 1,100° C, changing the molecular structure of the mineral, making it more reactive to sulfuric acid. A mixture of finely ground converted spodumene and sulfuric acid is heated to 250° C, forming lithium sulfate. Water is added to the mixture to dissolve the lithium sulfate. Insoluble portions are then removed by filtration. The purified lithium sulfate solution is treated with soda ash, forming insoluble lithium carbonate that precipitates from solution. The carbonate is separated and dried for sale or use by the producer as feedstock in the production of other lithium compounds.

Production of lithium carbonate from brine in Nevada is much less energy intensive than production from the spodumene. Brines enriched in lithium chloride—averaging about 300 parts per million when operation began in 1966—are pumped from the ground and progress through a series of evaporation ponds. Over the course of a year to 18 months, concentration of the brine increases to 6,000 parts per million lithium through solar evaporation. When the lithium chloride reaches optimum concentration, the liquid is pumped to a recovery plant and treated with soda ash, precipitating lithium carbonate. The carbonate is then removed through filtration, dried, and shipped.

Consumption and Uses

The aluminum, ceramics and glass, lubricating grease, and synthetic rubber industries consumed most of the lithium minerals and chemicals. These markets primarily were related to transportation; i.e., the aircraft and automotive industries. Industrial and consumer applications also used ceramics and glass. Estimated domestic consumption increased nearly 9% from 1993. Ceramics and glass production and aluminum smelters were the largest consumers of lithium carbonate and lithium concentrates in the United States, comprising an estimated 20% and 18% of the lithium market, respectively. Other consuming industries were synthetic rubber and pharmaceuticals, 13%; chemical manufacturing, 13%; miscellaneous chemicals, 12%; lubricants, 11%; batteries, 7%; and air treatment, 4%.[2]

Lithium carbonate and mineral concentrate additions in ceramics and glass manufacturing processes lower process melting points, reduce the coefficient of thermal expansion and the viscosity, and eliminate the use of more toxic chemicals. The manufacture of thermal-shock-resistant cookware (pyroceramics) consumed the majority of lithium used in the ceramics and glass industry domestically. The manufacture of black and white television picture tubes consumed significant amounts of lithium concentrates overseas. Low-iron spodumene and petalite were a source of lithium used to improve the physical properties of container and bottle glass and as a source of alumina, another important component of the glass. Glass manufacturers used lithium in container and bottle glass, enabling them to produce lighter weight, thinner walled products.

Aluminum producers added lithium carbonate to cryolite baths in aluminum potlines. The chemistry of the potline converts it to lithium fluoride, lowering the melting point of the bath, allowing a lower operating temperature for the potline, and increasing the electrical conductivity of the bath. Operators used these factors to increase production or reduce power consumption.

The third largest end use for lithium compounds is as catalysts in the production of synthetic rubbers and plastics and pharmaceuticals. N-butyllithium initiates the reactions between styrene and butadiene that form abrasion-resistant synthetic rubber and thermoplastic rubbers that require no vulcanization. Other organic lithium compounds are catalysts for the production of plastics like polyethylene. Lithium metal and compounds also are used by drug manufacturers in the production of a number of drugs including Vitamin A, some steroids, an anti-cholesterol drug, an analgesic, antihistamines, tranquilizers, sleep inducers, and contraceptives. Pharmaceutical-grade lithium carbonate is approved directly for the treatment for manic-depressive psychosis. This is the only treatment approved by the U.S. Food and Drug Administration in which lithium is consumed by the patient.

The multipurpose grease industry was another of the important end uses for lithium in 1994. Lithium hydroxide monohydrate was the compound used for the production of lithium lubricants. Lithium-base greases are favored for their retention of lubricating properties over a wide temperature range; good resistance to water, oxidation, and hardening; and formation of a stable grease on cooling after melting. These greases continued to be utilized in military, industrial, automotive, aircraft, and marine applications.

Almost all major battery manufacturers marketed some type of lithium batteries, and research and development continued for further substitution in applications that implement more conventional alkaline batteries. These batteries represent a growth area for lithium consumption, and new battery configurations continue to be developed. Continued interest in electrically powered vehicles spurred additional interest in battery research. New, more efficient types of rechargeable (secondary) lithium batteries have been developed and improved to meet the needs for this market and for electronic equipment such as portable telephones and video cameras. Work continued on lithium polymer and lithium ion batteries. These batteries are of particular interest because they take advantage of large power capacity available from lithium batteries without the safety problems encountered when these batteries contain lithium metal, a very reactive and volatile material when exposed to air and moisture.

Nonrechargeable (primary) lithium batteries offer improved performance over alkaline batteries at a slightly higher cost and have been commercially available for over 10 years. They were used in watches, microcomputers, and cameras, and, more recently, in small appliances, electronic games, and toys. The military purchased large and small lithium batteries for a variety of military applications. The Galileo spacecraft, launched in October of 1989 for its 6-year trip to explore the atmosphere of Jupiter, contained lithium sulfur dioxide batteries to power its scientific instruments when it reaches its destination. Recent modifications to the lithium sulfur dioxide battery have extended the life of the batteries to at least 10 years with little or no reduction of performance. The final disposition of lithium batteries has caused some concern in the past. Until recently, no technology had been developed for the safe and economic disposal of large lithium batteries, especially the military types. ToxCo, Inc., a hazardous waste remediation company based in Claremont, CA, developed a process for neutralization, disposal, and recycling of lithium batteries and built a commercial facility in Trail, British Columbia.[3]

Aircraft manufacturers in several countries have designed new aircraft using aluminum-lithium alloys for wing and fuselage skin or structural members. Use of aluminum-lithium alloys can reduce the weight of the aircraft by more than 10%, allowing significant fuel savings during the life of the aircraft. The alloys, which are 2% to 3% lithium by weight, are attractive to the aircraft and aerospace industry because of their reduced density and superior corrosion resistance compared to those of conventional aluminum alloys. These alloys face direct competition, however, from composite materials consisting of boron, graphite, or aramid fibers imbedded in polymers.

Small quantities of other lithium compounds were important to many industries. Lithium chloride and lithium bromide were used in industrial air-conditioning systems, commercial dehumidification systems, and in the production of sophisticated textiles. Sanitizers for swimming pools, commercial glassware, and public restrooms contained lithium hypochlorite, as did dry bleach for commercial laundries. Lithium metal was used as a scavenger to remove impurities from copper and bronze, and anhydrous lithium chloride was used as a component in fluxes for hard-to-weld metals such as steel alloys and aluminum.

Prices

The price for lithium carbonate, the largest volume lithium compound, increased 3% in 1994. Lithium hydroxide monohydrate remained about the same, and standard-grade lithium metal increased more than 7%. Price increases for other lithium products ranged from about 3% to nearly 9%. *(See table 2.)*

Foreign Trade

Total U.S. exports of lithium compounds

were about 5% lower in 1994 than they were in 1993. More than 50% of all U.S. exports of lithium compounds were to Germany, Japan, and the United Kingdom.

Imports of lithium compounds increased 5%. Cyprus Foote Mineral Co. owns a lithium brine operation in Chile; 98% of all lithium imports were from this source. Lithium ore concentrates from Australia, Canada, and Zimbabwe were consumed in the United States, but no import statistics were available. *(See tables 3 and 4.)*

World Review

A small number of countries throughout the world produced lithium ore and brine. Chile and the United States were the leading producers of lithium carbonate; significant quantities of lithium compounds and ore concentrates also were produced in Australia, Canada, Chile, China, Portugal, Russia, and Zimbabwe. Argentina, Brazil, and Namibia produced smaller quantities; production primarily consisted of concentrates. Rwanda, the Republic of South Africa, and Zaire are past producers of concentrates. Pegmatites containing lithium minerals have been identified in Austria, France, India, Ireland, Mozambique, Spain, and Sweden, but economic conditions have not favored development of the deposits. Lithium has been identified in subsurface brines in Argentina, Bolivia, China, and Israel. Companies in France, Germany, Japan, and the United Kingdom produced downstream lithium compounds from imported lithium carbonate.

Argentina.—Construction of the evaporation facilities neared completion at the Salar de Hombre Muerto in Catamarca Province. A lithium carbonate plant with the capacity to produce nearly 4,500 tons per year is expected to be started in 1995 with lithium carbonate production to begin in 1996 or 1997. If lithium carbonate demand expands as expected, production would be expanded to about 16,000 tons. Minera Antiplano, a wholly owned subsidiary of FMC, is investing about $45 million in the first phase of the project.[4]

Australia.—Gwalia Consolidated Ltd., the only lithium ore concentrate producer in Australia and the largest in the world, was building a lithium carbonate plant at its spodumene mine at Greenbushes, Western Australia. The plant was expected to be completed late in 1995 and will have the capacity to produce 5,000 tons of lithium carbonate per year. Initial production is planned to be 1,000 tons.[5]

The Gwalia lithium carbonate plant will use an unusual process in which calcined spodumene is leached directly with a slurry of soda ash at high temperature and pressure forming lithium carbonate. The lithium carbonate reacts with carbon dioxide to form lithium bicarbonate, a soluble compound that is separated from the silicate residue. The lithium carbonate is then reprecipitated. The process is believed to be less costly than the process used at other spodumene processing facilities, although not as low as recovering lithium carbonate from brines.[6]

Canada.—A feasibility study for construction of a spodumene mine and lithium carbonate plant in Quebec was underway. Lithos Corp., a new company formed through the merger of Wrightbar Mines Ltd. and Charlim Exploration Ltd., was examining the development of the Sirmac Lake spodumene deposit and other deposits in the Jonquiere region.[7]

Chile.—Sociedad Quimica y Minera de Chile (SQM), a Chilean fertilizer producer, was developing a second project on the Salar de Atacama for the potash that would be produced as a raw material for its potassium nitrate plant. Production of lithium carbonate is important to the economics of the project. Production of 9,000 tons per year of lithium carbonate, the second stage of the project, should begin by the end of the century.[8] Cyprus Foote has been recovering lithium carbonate from the same deposit since 1984.

Outlook

The health of the lithium industry is closely tied to the performance of the primary aluminum industry. Improved consumption of lithium in the aluminum industry has had a positive effect on lithium consumption. Demand for lithium compounds and minerals in the ceramics and glass industry continues to grow modestly. Similar increases are expected for the near future.

Demand for butyllithium is expected to continue to increase, and both domestic producers have increased production capacity to meet that demand. Demand for lithium metal for batteries and to some extent for alloys should increase, but total consumption of metal will remain small in comparison to the demand for lithium compounds for the short term. The fate of the lithium battery market will be largely dependant on the success of electric vehicles and whether the best type of battery for powering them finally is determined to be some form of lithium battery.

Other markets should remain relatively stable with slight growth. Lithium demand could increase dramatically if any of the new technology areas such as nuclear fusion were perfected. This is not expected to occur within the remainder of this century and probably not within the next 25 years.

The United States should remain the largest producer of lithium carbonate until production of lithium carbonate from the SQM project in Chile. At that time, Chile should become the leading producer of lithium compounds in the world.

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[1] Cyprus Amax Minerals Company 1994 10-K Report. 1995, p. 14.

[2] Cyprus Minerals Company 1992 Annual Report. 1993, p. 14.

[3] McLaughlin, W.J. Lithium Recycling and Disposal Techniques. Presented at the EV Battery Readiness Working Group, August 1994, Washington DC, 9 pp.

[4] Mining Magazine (London). FMC to Exploit Argentine Lithium. V. 171, No. 4, 1994, p. 230.

[5] F & S International Inc. press release. March 3, 1995. 1 page.

[6] Lithium Carbonate Project Description. Gwalia Consolidated Ltd. Sept. 1993, 4 pp.

[7] Industrial Minerals (London). Feasilbility Study on Lithium Mine and Plant. No. 326, 1994, p. 8.

[8] Metals Week. FMC Testing, Weighing Options in South America. V. 64, No. 11, 1993, p. 9-10.

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European Chemical News (London), monthly.

Industrial Minerals (London), monthly.

TABLE 1
SALIENT LITHIUM STATISTICS 1/

(Metric tons of contained lithium)

	1990	1991	1992	1993	1994
United States:					
Production 2/	W	W	W	W	W
Producers' stock changes 2/	W	W	W	W	W
Imports 3/	790	590	770	810	851
Exports 4/	2,600	2,400	2,100	1,700	1,700
Consumption:					
Apparent	W	W	W	W	W
Estimated	2,700	2,600	2,300	2,300	2,500
Rest of world: Production 2/	5,400 r/	5,000	5,700	5,900 r/	6,000 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits.

2/ Mineral concentrate and carbonate.

3/ Compounds, concentrate, ores, and metal.

4/ Compounds.

TABLE 2
DOMESTIC YEAREND PRODUCERS' 1/ AVERAGE PRICES OF LITHIUM AND LITHIUM COMPOUNDS

	1993		1994	
	Dollars per pound	Dollars per kilogram	Dollars per pound	Dollars per kilogram
Lithium bromide, 54% brine: Truckload lots, delivered in drums	5.47	12.06	5.67	12.50
Lithium carbonate, technical: Truckload lots, delivered	1.91	4.21	2.00	4.41
Lithium chloride, anhydrous, purfied: Truckload lots, delivered	4.83	10.65	4.84	10.67
Lithium fluoride	6.87	15.14	7.14	15.74
Lithium hydroxide monohydrate: Truckload lots, delivered	2.59	5.71	2.55	5.62
Lithium metal ingot, standard grade: 1,000-pound lots, delivered	33.60	74.05	35.98	79.32
Lithium sulfate, anhydrous	4.16	9.17	4.45	9.81
N-butylithium in n-hexane (15%): Truckload lots, delivered	19.34	42.64	20.20	44.53

Source: U.S. lithium producers and Chemical Marketing Reporter v. 245, No. 1, 1994, p. 25 and 28.

TABLE 3
U. S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY 1/

Compound and country	1993		1994	
	Gross Weight (metric tons)	Value (thousands)	Gross Weight (metric tons)	Value (thousands)
Lithium carbonate:				
Australia	38	$174	119	$454
Canada	892	3,490	875	3,230
Germany	1,440	4,610	906	3,010
India	42	183	77	264
Japan	1,650	6,570	1,020	3,610
Korea, Republic of	115	387	97	319
Mexico	120	479	121	470
Netherlands	789	2,670	300	1,010
Taiwan	73	267	90	321
United Kingdom	1,000	2,820	933	2,880
Venezuela	--	--	613	1,890
Other	91	450	(2/)	242
Total	6,250	22,100	5,200	17,700
Lithium carbonate U.S.P. 3/				
France	(2/)	(2/)	1	7
Germany	1	34	(2/)	(2/)
Korea, Republic of	--	--	1	7
Malaysia	1	15	1	15
Mexico	1	4	19	75
New Zealand	2	28	(2/)	12
United Kingdom	3	21	7	62
Venezuela	--	--	28	190
Other	(2/)	33	1	26
Total	8	135	58	393
Lithium hydroxide:				
Argentina	97	361	110	471
Australia	62	275	149	584
Canada	65	310	88	394
Germany	447	1,840	711	3,210
India	350	1,270	221	852
Japan	777	3,700	693	3,360
Korea, Republic of	161	629	308	1,280
Mexico	228	1,050	143	608
Netherlands	72	338	40	159
Saudia Arabia	69	309	50	150
Singapore	91	407	204	992
South Africa, Republic of	3	14	76	796
Thailand	111	505	83	373
United Kingdom	301	942	441	1,850
Other	226	1,250	283	1,521
Total	3,060	13,200	3,600	16,600

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Pharmaceutical-grade lithium carbonate.

Source: Bureau of the Census.

TABLE 4
U. S. IMPORTS FOR CONSUMPTION OF LITHIUM CHEMICALS 1/

	Compounds			
	1993		1994	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Lithium carbonate:				
Chile	4,160	$11,700	4,450	$12,500
China	71	250	50	177
France	1	5	(3/)	(3/)
Hong Kong	52	188	(3/)	(3/)
Russia	1	4	(3/)	(3/)
Other	2	20	(3/)	14
Total 1/	4,290	12,100	4,500	12,700
Lithium hydroxide:				
China	2	18	(3/)	(3/)
Japan	21	198	25	253
Russia	(3/)	1	(3/)	21
Switzerland	--	--	3	19
Other	(3/)	21	1	37
Total	24	238	29	330

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Customs value.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 5
LITHIUM MINERALS AND BRINE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina, spodumene and amblygonite	69 r/	287 r/	620 r/	300 r/ e/	400
Australia, spodumene	40,000 e/	40,400 4/	42,500 4/	52,900 r/ e/	53000
Brazil, concentrates	475	1,560	1,600 e/	1,600 e/	1600
Canada, spodumene e/ 5/	12,000	12,000	18,500	18,900 r/	20000
Chile, carbonate from subsurface brine	9,080	8,580	10,800	10,400 r/	10500
China (minerals not specified) e/ 6/	15,000	15,500	15,500	15,500	16000
Namibia:					
Amblygonite	54	20	5	5 r/	5
Lepidolite	80	33	93	88 r/	90
Petalite	1,130	1,140	1,060	649 r/	700
Portugal, lepidolite e/	10,600 r/ 7/	10,000	9,000	9,000 r/	9000
Russia (minerals not specified) e/ 6/ 8/	XX	XX	45,000	40,000	40000
U.S.S.R. e/ 9/	55,000	50,000	XX	XX	XX
United States, spodumene and subsurface brine	W	W	W	W	W
Zimbabwe (minerals not specified)	19,100	9,190	12,800	18,100 r/	19000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Table includes data available through Apr. 3, 1995.

3/ In addition to the countries listed, other nations may produce small quantities of lithium minerals, but output is not reported and no valid basis is available for estimating production levels.

4/ Data are for year ending June 30 of that stated.

5/ Based on all of Canada's spodumene concentrates (Tantalum Mining Corp. of Canada Ltd.'s Tanco property).

6/ These estimates denote only an approximate order of magnitude; no basis for more exact estimates is available.

7/ Reported figure.

8/ All production in the U.S.S.R. for 1990-91 came from Russia.

9/ Dissolved in Dec. 1991.

MAGNESIUM

By Deborah A. Kramer

Tight U.S. magnesium supplies were the hallmark of 1994. Domestic production declined as one producer closed nearly one-third of its annual capacity; imports from China, Russia, and Ukraine essentially ceased by midyear as a result of antidumping determinations; and domestic demand increased for aluminum alloying and diecasting. As a result of the tight supply situation, average free market prices for primary metal rose by more than $1,000 per metric ton during the year, and producers' inventories declined by 35%. Demand was expected to continue to rise as U.S. auto manufacturers continued to introduce new magnesium components in 1996, 1997, and 1998 models. New and expanded diecasting facilities were scheduled to be constructed to handle the increased demand.

The tight supply situation that was affecting the United States was also prevalent throughout the rest of the world. Closure of Japan's last magnesium plant, along with an accompanying temporary shutdown in France exacerbated the tight supplies. New magnesium extraction facilities were being planned in Australia, Canada, and Israel, but the first of these plants to come on-stream (the Israeli plant) was not scheduled to begin operation until 1996. Production at the other two plants was not scheduled to begin until near the end of the 1990's.

Legislation and Government Programs

Because of the high import levels in 1993, Russia lost its duty-free status for magnesium under the Generalized System of Preferences (GSP), effective January 1, 1994. The U.S. Trade Representative revoked the status for magnesium because Russia had exceeded its competitive need limit on exports, which was not more than 50% of total U.S. imports. Kazakhstan and Ukraine were granted duty-free status under the GSP for exports of specific products, including magnesium. For Ukraine, GSP status took effect on March 23, and for Kazakhstan, GSP status became effective on March 4.[1]

On March 31, the International Trade Commission (ITC) began a preliminary investigation on assessing antidumping duties on pure and alloy magnesium from China, Russia, and Ukraine. The suit was initiated by Magnesium Corp. of America (MagCorp). Products covered by this investigation are classified under sections 8104.11.00, 8104.19.00, and 8104.20.00 of the Harmonized Tariff Schedule.[2] The first hearing on the petition was held on April 21, and the ITC was scheduled to vote on whether the U.S. industry was injured on May 11.

As a result of the May 11 vote, the ITC decided that the U.S. industry was not injured by alloy imports from Ukraine, but appeared to be injured by imports of pure magnesium from all three countries under investigation and by alloy imports from China and Russia. This decision was forwarded to the Department of Commerce on May 16.[3] At the end of June, Dow Chemical formally entered the antidumping suit filed by MagCorp.[4]

At the preliminary determination, held on October 27, the International Trade Administration (ITA), Department of Commerce, made a preliminary determination that imports of magnesium from China, Russia, and Ukraine were being sold in the United States at less than fair value. Preliminary dumping margins for primary magnesium from all three countries and for magnesium alloy from China and Russia were established, but unusually, these margins were directly linked to the importing company. For pure magnesium from Ukraine, the dumping margin range was 36.05% to 53.99%; for China the dumping margins were 108.26% for pure magnesium and 79.38% for magnesium alloy; and for Russia, the dumping margins were 0% to 64.12% for pure magnesium and 0% to 107.89% for magnesium alloy. Under the ruling, importers were required to post a bond or a cash deposit equivalent to the dumping margin when magnesium was imported into the United States. The final determination on this case was scheduled for March 1995.[5]

The U.S. magnesium industry reportedly objected to the Department of Commerce's preliminary antidumping determination for Russia and Ukraine by filing allegations of significant ministerial errors on November 14. The filings alleged that incorrect figures were used for valuing carnallite, transportation, and labor, and that Commerce erroneously deducted some materials costs.[6]

Production

U.S. primary magnesium production was about 3% less than that of 1993, and producers were operating at about 91% of rated yearend capacity. *(See tables 1 and 2).*

At the beginning of February 1994, MagCorp announced that it would make a significant reduction in magnesium production, but declined to give an actual percentage or tonnage figure for the cutback. Company officials said that the production cut was in response to a continuing increase in magnesium imports from the former U.S.S.R. and China. Industry analysts estimated that the total cutback was about 20% to 25% of MagCorp's total output. As a result of the decrease in the production rate, MagCorp reportedly laid off more than 50 of the 560 employees at the Rowley, UT, plant.

Debottlenecking the batch process at Northwest Alloys Inc.'s Addy, WA, plant reportedly will allow the company to increase its production by 15% to 20% in 1995, according to officials. Northwest Alloys has been operating five furnaces at its plant, with a sixth furnace as insurance in case of operational problems.

In early December, Dow Magnesium announced that it would permanently close the idled portion of the magnesium facility at its Freeport, TX, complex. Dow's plant B was originally idled in September 1993 and was estimated to have an annual capacity of 30,000 tons. The closure left Dow with 65,000 tons of annual capacity in Freeport.[7]

MagCorp announced that it completed labor negotiations with its union on November 23, 1994, and signed a new 3-year agreement retroactive to November 1. Contract terms were not disclosed. United Steelworkers of America union members had been working without a contract since the end of August.

Consumption

Increased domestic consumption of aluminum resulted in an accompanying increase in magnesium consumption in 1994. Also additional quantities of aluminum-base new scrap were generated, again with a similar increase in magnesium recovered from this source. Diecasting continued to grow and has become the second-largest market for magnesium, after aluminum alloying. *(See tables 3 and 4).*

Ford Motor Co. announced that when the new Mustang Cobra models are introduced, they would contain a one-piece magnesium alloy diecasting for the frames in the driver's side seat cushions. This marked the first use of magnesium in an internal seat component in a North American-built car. The one-piece magnesium component, weighing 1.6 kilograms, would replace multipiece steel assemblies in this application. Although the number of Mustang Cobras to be built is limited to 5,000 to 6,000, industry analysts expected that this would be the first of more internal seat applications for magnesium.[8]

Chrysler Corp. announced that it approved Hydro Magnesium's recycled, refined AZ91D ingot per the company's material standard MS 2413. After conducting comprehensive tests on the recycled material, Chrysler determined that this magnesium was equivalent to conventional electrolytic material in quality.[9]

General Motors Corp. (GM) approved the use of magnesium alloy steering column supports in three redesigned car lines that were due out in 1996 and 1997. The new supports will weigh about 1.6 kilograms each.[10] Chrysler, however, postponed plans to put magnesium intake manifolds on its 6-cylinder, 4.0-liter Jeep engines in 1997. Chrysler finalized plans to install magnesium steering column brackets on the 1997 models of its Dodge Dakota pickup trucks. The brackets, weighing about 1.4 kilograms each, were expected to require about 300 tons of magnesium alloy annually.[11]

Meridian Technologies announced that it had won a contract to supply magnesium instrument panels for GM's 1998 series of light trucks. At 4.5 kilograms per part, the contract would amount to about 4,500 tons of magnesium per year.[12] In addition, Meridian announced that it received a letter of intent from New Venture Gear, Detroit, MI, to supply magnesium transfer cases for all of GM's light trucks, beginning with the 1997 models. The transfer cases will consume about 5,900 tons of magnesium annually. Because of the increased diecasting business, Meridian planned to construct a third North American diecasting plant. The new plant, which was estimated to be about the same size as the company's Eaton Rapids, MI, plant, would be constructed in either Michigan or Ontario, Canada. No timetable was set for plant construction.[13]

GM reportedly was completing plans for three new magnesium alloy automobile components that were projected to consume about 5,000 tons of magnesium alloys annually. The new components, instrument panel support beams in three different vehicle lines, were scheduled to be introduced over a 2-year period, beginning in late 1995. The largest of the support beams, to be installed in standard-size vans, would weigh 15 kilograms each, and would be the largest magnesium alloy component produced in high volumes in North America. Industry sources estimated that the new components will replace at least 17,000 tons of steel that was being used in these applications.

Chrysler selected Hayes-Albion Corp. to supply die-cast magnesium steering column brackets for its 1997 intermediate pickup truck models. The brackets, weighing 1.4 kilograms each, replaced steel components, weighing 4.5 kilograms each.[14] Ford planned to replace steel frames for the middle bench seats in one of its 1997 model minivans with magnesium components. The magnesium frames weigh about 6.8 to 8.2 kilograms, about one-third the total weight of the steel component. Total consumption of magnesium for this application was estimated to be about 3,000 tons per year.[15] Hayes-Albion also was selected as the supplier of the die-cast magnesium steering column support brackets for GM's next generation of compact cars. This application was expected to require about 2,500 tons of magnesium annually when full production levels are reached. The first production of the new compact models was scheduled for 1997, with a complete phase-in over a 2-year period.[16]

Toyota Motor Manufacturing U.S.A. Inc. specified die-cast magnesium valve covers for the V-6 engines in some of its sedans manufactured in the United States. Representing about 210 tons of annual magnesium consumption, the valve covers would be manufactured by Diemakers Inc., Monroe City, MO.[17]

In December, Spartan Aluminum Products broke ground on a magnesium diecasting plant in Mexico, MO, with the initial phase expected to be operational by mid-1996. Cost of the initial phase was $15 million and included four 1,200-ton and three 1,000-ton diecasting machines. The new plant was being constructed in response to increased demand from the automotive industry and would have the flexibility to double its initial size to provide capacity for programs under development. Spartan also was continuing an expansion of its existing plant in Sparta, IL.[18]

By installing new equipment, Magnesium Aluminum Corp. expected to increase its productivity and enhance the quality of its products. The magnesium diecaster was installing a new system for eliminating porosity, five electric melting furnaces, and a 600-ton cold-chamber diecasting machine. Magnesium Aluminum produced diecastings for the automotive, electronics, materials handling, and telecommunications markets.[19]

MSI-Magnesium Services announced plans to construct a 10,000-ton-per-year magnesium recycling plant in the midwestern United States. Although a specific location was not disclosed, the facility would be nearby many of the magnesium diecasters. Initial production at the secondary facility was scheduled for late 1996.[20]

Data for magnesium metal are collected from two voluntary surveys of U.S. operations. Of the 116 companies canvassed for magnesium consumption data, 82% responded, representing 49% of the primary magnesium consumption shown in tables 1 and 3. Data for the 21 nonrespondents were estimated based on prior-year consumption levels and other factors.

Stocks

Producer stocks of primary magnesium were 11,600 tons at yearend 1994, a decrease of 35% compared with yearend 1993 stocks of 17,800 tons. Stocks of metal and alloy held by consumers at yearend 1994 were essentially unchanged at 7,730 tons, compared with the yearend 1993 level of 7,770 tons. Consumer stocks of secondary magnesium increased to 700 tons at yearend 1994 from 388 tons at yearend 1993.

Prices

Primary magnesium prices quoted in trade journals increased significantly in 1994. The average Metal Bulletin free market price was $2,260 per ton at the beginning of the year and rose to $3,125 per ton by yearend. The Metals Week European average free market price rose from $2,350 per ton at the beginning of the year to $3,150 per ton by the end of 1994. The average U.S. spot dealer import price, quoted in Metals Week, increased from $1.19 per pound to $1.59 per pound by yearend. The average Metals Week U.S. spot Western price also increased from $1.45 per pound to $1.63 per pound in 1994.

Foreign Trade

With the suit brought by MagCorp in mid-1994, imports of primary magnesium from Russia and Ukraine, which had constituted much of the total imports in the first half of 1994, were essentially eliminated beginning in July. As a result, U.S. imports of primary magnesium were 35% lower than those in 1993. *(See tables 5 and 6).*

World Review

The International Magnesium Association reported that producers' yearend 1994 inventories were 23,300 tons, a 45% decrease from the yearend 1993 level of 42,400 tons.

In July, Norsk Hydro announced that it was increasing production at both its plants in Norway and Canada. Increased demand by the automotive market was responsible for the company's scheduled production increases.[21] To meet its sales requirements, Pechiney reportedly was purchasing magnesium from Russia, despite the antidumping investigation initiated by the European magnesium producers. Even though the European trade suit was initiated before that in the United States, producers expected that the European trade case will not be settled before the end of the year.[22]

Meridian Technologies, along with its joint-venture partner Teksid of Italy, planned to construct a 100,000-square-foot magnesium diecasting plant in Europe. The two companies planned to form a new European company called Meridian International. The new plant was planned to provide magnesium for a European automotive components manufacturer that would in turn supply components for four European automakers. *(See tables 7, 8, and 9).*

Australia.—The Australian Magnesium Research and Development Project (AMRDP) reportedly signed an agreement with Alcan Aluminium Ltd. to acquire electrolytic cell technology for its planned primary magnesium plant. On May 17, two of the original partners in the joint venture, Ube Industries and MIM Holdings, withdrew to concentrate on their respective core businesses. These two companies accounted for 49% of the total investment in the project. The remaining two partners, Queensland Metals Corp. and the Government research organization CSIRO, planned to enter in discussions with other parties to enter the joint venture. AMRDP has been operating a minipilot magnesium production plant since the beginning of 1992 and planned to construct a 60,000-ton-per-year plant in 1996. A prefeasibility study stated that the plant would be able to produce magnesium at an operating cost in the range of 38 to 62 cents per pound.

Brazil.—The Secretary of Foreign Trade in Brazil began an antidumping investigation of magnesium imports from Russia, Ukraine, and the United States after a complaint was filed by Brazil's sole magnesium producer, Brasmag. The complaint alleged dumping margins of 36% for imports from Russia and Ukraine and 25% for imports from the United States. The investigation, which was opened in early December 1994, covered the period from January 1993 to June 1994.[23]

Canada.—The Alberta Government hired a marketing firm to try to sell the High River primary magnesium plant that closed in 1991. When the Government took over the plant in April 1991, it made good on a loan guarantee of C$102.75 million; since then the Government has written off about C$54 million of the debt. Government officials hoped to sell the plant by the end of 1994.[24]

Noranda Minerals announced that it would construct a 56,000-ton-per-year primary magnesium plant near Thetford Mines, Quebec, in two stages. Construction of the first stage of 28,000 tons per year was expected to begin in 1997, with completion scheduled for 1999, and construction of the second phase would begin directly after the first is completed. Total plant construction cost was estimated to be C$500 million; a C$25 million pilot plant to verify the novel technology began operating in fall 1994. The new plant would produce magnesium and magnesium alloys from asbestos tailings using patented technology.[25]

Israel.—Israel's Dead Sea Works (DSW) announced that the company was negotiating with Germany's Volkswagen to be a joint-venture partner in DSW's primary magnesium under construction in Sdom. After a visit by Volkswagen's president, the two companies agreed to set up a joint body of experts to study future cooperation ideas. DSW began construction of a 27,500-ton-per-year magnesium production plant in the summer of 1993, with completion scheduled for early 1996 at a cost of $250 million.[26]

Japan.—Ube Industries Ltd. planned to close its 8,500-ton-per-year primary magnesium plant in September. This was the third magnesium plant in Japan that closed within 6 years; Japan Metal and Chemicals closed its plant in 1992, and Furukawa Magnesium closed its plant in 1989. The closure of Ube Industries' plant left Japan with no primary magnesium production capacity. High production costs and the appreciation of the yen were cited as reasons for the closure.[27] In July, Ube Industries announced that it would import magnesium from Timminco of Canada and Norsk Hydro of Norway. Ube planned to market the metal under its brand name and will melt or cast some of the metal to the users' specifications. Total level of imports was estimated to be 7,000 tons per year, about the same level that Ube was producing before the shutdown.[28]

Norway.—Norsk Hydro reportedly received final approval for construction of a 10,000-ton-per-year magnesium recycling plant in Porsgrunn, which was scheduled to come on-stream by the end of 1995. The new recycling plant would be able to handle all types of scrap and produce material suitable as a prerequisite for diecasting as well as a source of high-purity magnesium alloys.[29]

Former U.S.S.R.—Production of magnesium in Kazakhstan, Russia, and Ukraine was estimated to have decreased in 1994. Price hikes that increased the electric power cost to about 4 cents per kilowatt-hour were assumed to be partially responsible for the drop in production. Ukraine producer Zaporzhye stopped magnesium production because it has not been able to pay for carnallite, its raw material source, for 8 months. The carnallite mine in the Urals has stopped supplying carnallite until the debts are paid. The other five plants in the aforementioned countries were all operating at reduced rates.[30]

United Kingdom.—Metal Casting reportedly was constructing a new magnesium diecasting plant in Wolverhampton, United Kingdom. The new plant would include a 700-ton, hot-chamber diecasting machine designed to produce 500,000 magnesium cam covers per year for the European market. Production was scheduled to begin in mid-1995.[31]

Outlook

If conditions continue as they have in the past few years, demand for magnesium is expected to continue to grow rapidly for automotive diecastings. Continued short supply for magnesium, however, could result in significant price escalation that may discourage auto manufacturers from specifying magnesium for any new components. If this happens, magnesium's penetration into this market could be severely retarded. Because this is the major growth area for magnesium, both currently and in future projections, overall demand for magnesium could remain stagnant or even decline.

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TABLE 1
SALIENT MAGNESIUM STATISTICS 1/

(Metric tons unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production:					
Primary magnesium	139,000	131,000	137,000	132,000	128,000
Secondary magnesium	54,800	50,500	57,000	58,900	62,100
Exports	51,800	55,200	52,000	38,800	45,200
Imports for consumption	26,800	31,900	11,800	37,200	29,100
Consumption, primary	96,100	91,900	93,800	101,000	112,000
Price per pound	$1.43-$1.63	$1.43	$1.46-$1.53	$1.43-$1.46 2/	$1.63 2/
World: Primary production	354,000 r/	342,000 r/	307,000 r/	281,000 r/	267,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Yearend Platt's Metals Week U.S. spot western price.

TABLE 2
U.S. MAGNESIUM METAL PRODUCERS, BY LOCATION, RAW MATERIAL, AND PRODUCTION CAPACITY IN 1994

Company	Plant location	Raw material	Annual capacity (metric tons)
The Dow Chemical Co.	Freeport, TX	Seawater	65,000
Magnesium Corp. of America	Rowley, UT	Lake brines	38,000
Northwest Alloys Inc.	Addy, WA	Dolomite	38,000
Total			141,000

TABLE 3
MAGNESIUM RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY 1/

(Metric tons)

	1993	1994
KIND OF SCRAP		
New scrap:		
Magnesium-base	3,220	2,790
Aluminum-base	25,100	29,700
Total	28,300	32,500
Old scrap:		
Magnesium-base	4,320	4,330
Aluminum-base	26,300	25,300
Total	30,600	29,600
Grand total	58,900	62,100
FORM OF RECOVERY		
Magnesium alloy ingot 2/	W	W
Magnesium alloy castings	1,090	924
Magnesium alloy shapes	413	476
Aluminum alloys	51,600	55,200
Zinc and other alloys	2	12
Other 3/	5,800	5,510
Total	58,900	62,100

W Withheld to avoid disclosing company proprietary data; included in "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes secondary magnesium content of both secondary and primary alloy ingot.

3/ Includes chemical and other dissipative uses and cathodic protection, as well as data indicated by symbol "W."

TABLE 4
U.S. CONSUMPTION OF PRIMARY MAGNESIUM, BY USE 1/

(Metric tons)

Use	1993	1994
For structural products:		
Castings:		
Die	11,400 r/	13,600
Permanent mold	746	911
Sand	397	565
Wrought products:		
Extrusions	7,430	5,630
Other 2/	2,440	2,060
Total	22,400 r/	22,800
For distributive or sacrificial purposes:		
Aluminum alloys	46,500	61,100
Cathodic protection (anodes)	4,720	2,670
Chemicals	653	492
Iron and steel desulfurization	12,500	13,500
Reducing agent for titanium, zirconium, hafnium, uranium, beryllium	9,090	7,230
Other 3/	5,120 r/	3,980
Total	78,700 r/	89,000
Grand total	101,000	112,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes sheet and plate and forgings.

3/ Includes nodular iron, scavenger, deoxidizer, and powder.

TABLE 5
U.S. EXPORTS OF MAGNESIUM, BY COUNTRY 1/

Country	Waste and scrap		Metal		Alloys (gross weight)		Powder, sheets, tubing, ribbons, wire, other forms (gross weight)	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
Australia	--	--	2,990	$5,660	22	$42	163	$708
Belgium	--	--	1,660	5,500	85	276	419	1,310
Canada	1,960	$4,480	5,510	15,400	1,140	3,530	726	3,340
Japan	--	--	7,450	19,300	188	1,120	331	2,410
Korea, Republic of	16	24	177	519	158	1,120	4,940	1,600
Netherlands	--	--	7,490	19,800	12	37	595	1,800
Other r/	35	128	1,230	5,690	348	2,100	1,160	7,620
Total	2,010	4,640	26,500	71,900	1,950	8,220	8,340	18,800
1994:								
Australia	--	--	3,110	5,930	--	--	103	380
Belgium	--	--	8,060	22,400	263	619	2,700	7,040
Canada	1,760	4,060	2,490	6,810	4,600	12,000	838	2,690
Japan	--	--	6,290	16,100	290	1,310	468	2,880
Korea, Republic of	--	--	398	1,050	198	994	7,090	2,220
Netherlands	--	--	4,030	6,920	4	49	33	128
Other	81	213	1,260	6,520	281	1,950	835	5,660
Total	1,840	4,280	25,600	65,700	5,630	16,900	12,100	21,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MAGNESIUM, BY COUNTRY 1/

Country	Waste and scrap		Metal		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, other forms (magnesium content)	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
Canada	517	$742	802	$2,390	5,460	$19,000	102	$458
China	1	3	1,150	2,750	919	2,390	--	--
Mexico	1,080	1,380	--	--	--	--	1,330	3,940
Russia	272	463	16,600	35,800	773	1,640	1	6
Ukraine	--	--	4,220	8,580	17	40	--	--
United Kingdom	300	422	132	295	252	1,930	1	78
Other r/	1,290	1,520	1,290	3,260	664	2,580	37	143
Total	3,460	4,520	24,200	53,100	8,080	27,500	1,470	4,620
1994:								
Canada	442	794	309	972	8,070	27,900	886	3,150
China	213	307	780	1,460	37	103	--	--
Mexico	514	766	975	2,600	--	--	17	48
Russia	293	421	11,700	26,400	104	230	70	193
Ukraine	--	--	1,280	3,000	--	--	--	--
United Kingdom	358	526	(2/)	2	430	2,380	4	79
Other	1,100	1,370	716	1,770	906	3,170	4	37
Total	2,920	4,190	15,700	36,200	9,540	33,800	981	3,510

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 7
WORLD ANNUAL PRIMARY MAGNESIUM PRODUCTION CAPACITY, 1/ DECEMBER 31, 1994, BY CONTINENT AND COUNTRY 2/

(Metric tons)

Continent and country	Capacity	
North America:		
Canada	49,000	
United States	141,000	
Total	190,000	
South America: Brazil	10,600	
Europe:		
France	17,000	
Kazakhstan	65,000	3/
Norway	41,000	
Russia	95,000	3/
Ukraine	54,000	3/
Total	272,000	
Asia:		
China	26,000	
India	900	
Total	26,900	
World total	500,000	

1/ Includes capacity at operating plants as well as at plants on standby basis.

2/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes magnesium production capacity that is used exclusively for titanium production as follows: Kazakhstan, 40,000 metric tons; Russia, 35,000 metric tons; and Ukraine, 15,000 metric tons.

TABLE 8
MAGNESIUM: WORLD PRIMARY PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Brazil e/	8,700	7,800	7,300	9,700	9,700
Canada	25,300 r/	35,500	25,800 r/ e/	23,000 r/ e/	28,900
China e/	5,900	8,600	10,600 r/	11,800 r/	11,000
France	14,000 e/	14,000 e/	13,700	10,900 r/	8,800
Italy	5,730	3,920	1,210	-- e/	--
Japan	12,800	11,600	7,120	7,470 r/	3,410 3/
Kazakhstan e/	XX	XX	20,000	20,000	15,000
Norway	48,200	44,300	30,400	27,300	27,600 3/
Russia e/ 4/	XX	XX	40,000	30,000	25,000
Serbia and Montenegro 5/	XX	XX	4,060 r/	-- e/	2,000
Ukraine e/	XX	XX	10,000	9,000	7,000
U.S.S.R. e/ 6/	88,000	80,000	XX	XX	XX
United States	139,000	131,000	137,000	132,000	128,000 3/
Yugoslavia 5/ 7/	5,790	5,360 r/	XX	XX	XX
Total	354,000 r/	342,000 r/	307,000 r/	281,000 r/	267,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 12, 1995.

3/ Reported figure.

4/ Includes secondary.

5/ All production in Yugoslavia for 1990-91 came from Serbia and Montenegro.

6/ Dissolved in Dec. 1991.

7/ Dissolved in Apr. 1992.

TABLE 9
MAGNESIUM: WORLD SECONDARY PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Brazil e/	1,600	1,600	1,600	1,600	1,600
Japan	23,300	17,200	13,000	13,200	19,000 3/
U.S.S.R. e/ 4/	7,500	7,000	6,500	6,000	5,000
United Kingdom e/ 5/	900	800	800	500	500
United States	54,800	50,500	57,000	58,900	62,100 3/
Total	88,100	77,100	78,900	80,200	88,200

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 12, 1995.

3/ Reported figure.

4/ Dissolved in Dec. 1991; however, information is inadequate to formulate reliable estimates for individual countries.

5/ Includes alloys.

MAGNESIUM COMPOUNDS

By Deborah A. Kramer

Domestic production of magnesium compounds from all sources declined by 10% from that of 1993, but apparent consumption remained about the same. Refractory applications accounted for about 67% of total U.S. demand for magnesium compounds, the same as in 1993. Imports of dead-burned magnesia, particularly from China, made up for the shortfall in domestic production. U.S. magnesium compounds producers continued to target acid neutralization as a growth application for magnesium hydroxide [$Mg(OH)_2$] and magnesia.

Production

Production of refractory magnesia and $Mg(OH)_2$ decreased in 1994, continuing declines begun in 1989 and 1991, respectively. Although total $Mg(OH)_2$ production declined, the portion of the total that was consumed for water neutralization applications increased significantly. The overall drop in $Mg(OH)_2$ production was a result of lower demand for domestically produced magnesia for refractories.

In February, Clearwater Inc. announced the start-up of a new 30,000-ton-per-year $Mg(OH)_2$ production facility in Neville Island, PA. The plant produced $Mg(OH)_2$ by pressure hydrating magnesium oxide, most of which was imported from China. Magnesium hydroxide produced at this location was expected to be used for acid neutralization and heavy metals removal.[1] By the end of 1994, Martin Marietta Magnesia Specialties Inc. had purchased the Magneclear Div. of Clearwater. This purchase, combined with Martin Marietta's existing $Mg(OH)_2$ operations in Michigan, increases the company's total $Mg(OH)_2$ slurry production capacity to about 100,000 tons per year. Earlier in 1994, the company had expanded its merchant $Mg(OH)_2$ capacity to between 45,000 and 64,000 tons per year.[2]

Morton International Inc. purchased the trademarks, trade names, rights, and technology to manufacture magnesium compounds previously made by Marine Magnesium Co. in California. Marine Magnesium's facility closed at the end of 1993 when the company's lease ran out. Morton planned to produced Marine Magnesium's products at Morton's plant in Manistee, MI. Morton acquired products serving the pharmaceutical, food, cosmetic, and paper markets in the transaction.[3] *(See tables 1 and 2.)*

Data for magnesium compounds were collected from one voluntary survey of U.S. operations. Of the 18 operations canvassed, 67% responded, representing 35% of the magnesium compounds shipped and used shown in table 3. Data for the six nonrespondents were estimated based on prior-year consumption levels and other factors.

Two companies in the United States produced olivine—Unimin Corp., which purchased the operations of Applied Industrial Materials Corp. in April 1994, and Olivine Corp. Unimin operated two mines, one in North Carolina and and one in Washington, and processing plants in Indiana, North Carolina, and Washington; Olivine operated one mine and one processing plant in Washington.

The largest magnesite production facilities in the world are in China, North Korea, and Russia. Together, these three countries account for 61% of the world magnesite production capacity. Japan and the United States account for 61% of the world's magnesium compounds production capacity from seawater or brines. Fused magnesia is produced in Australia, Canada, France, Israel, Japan, Mexico, the United Kingdom, and the United States.

Norway, the world's principal producer of olivine, supplies its domestic needs and is a major world supplier of olivine. Countries with smaller output include Austria, Italy, Japan, Mexico, Spain, Sweden, and the United States.

Consumption

Dead-burned magnesia refractories for use in metal, cement, and glass production furnaces continued to be the primary application for magnesium compounds in the United States, representing about 67% of the total U.S. demand for magnesium compounds.

In 1994, agricultural applications (animal feed and fertilizer) were the dominant use for caustic-calcined magnesia, accounting for 28% of U.S. shipments. The following categories, with the individual components in parentheses in declining order, were the other end-use sectors for caustic-calcined magnesia: metallurgical (water treatment, refractories, and electrical), 26%; chemical, 22%; manufacturing (rayon, fuel additives, rubber, pulp and paper, fluxes, and foundry), 17%; construction (oxychloride and oxysulfate cements and general construction), 3%; pharmaceuticals and nutrition (medicinal and pharmaceutical, sugar, and candy), 1%; and unspecified uses, 2%.

Magnesium carbonate was used principally as a chemical intermediate and in rubber processing. Magnesium hydroxide was used mainly in the chemical industries. Magnesium sulfate was used mostly in pharmaceuticals and animal feed.

Magnesium chloride was used mainly as a chemical intermediate. Magnesium chloride brines were used principally for road dust and ice control.

Foundry uses remained the largest application for olivine in the United States, accounting for 78% of consumption of domestically produced material. Refractory applications accounted for 9% of U.S. demand, sandblasting and other abrasive uses consumed 7%, and slag control accounted for 6%. *(See table 3.)*

AP Green Industries Inc. signed a letter of intent to acquire the assets of General Refractories Co., U.S. Refractories Div. According to General Refractories, the company is being sold because the owner intended to retire from the business. General Refractories' nine plants throughout the United States, which all are included in the sale, produce a range of refractory materials including magnesium-carbon and chrome-magnesia products.[4]

A review of the magnesia industry was

published that discussed the varied end uses for caustic-calcined magnesia and $Mg(OH)_2$.[5]

Prices

Yearend magnesium compounds prices quoted in Chemical Marketing Reporter did not change from those at yearend 1993. However, the publication ceased citing a $Mg(OH)_2$ price.

U.S. olivine prices, quoted in Industrial Minerals, were $62 to $109 per ton for foundry grade and $50 to $78 per ton for aggregate material. All prices were quoted f.o.b. mine or plant. *(See table 4.)*

Foreign Trade

Olivine trade data are not reported separately by the Bureau of the Census, but some trade information is available from the Journal of Commerce Port Import/Export Reporting Service (PIERS). This service only reports material that travels by ship. According to PIERS, 175,000 tons of olivine was imported into the United States from Norway. A total of 813 tons of olivine was exported in 1994. Chile (64%) and Peru (15%) were the principal destinations. *(See tables 5, 6, 7, and 8.)*

World Review

Australia.—Queensland Metals Corp. Ltd. (QMC) continued to expand its operations, both in scope and in size. The company announced that it would form a joint venture with the French firm Mines de la Lucette S.A. (MDL) to develop and market QMC's magnesium hydroxide flame retardants. Under the joint venture, QMC (Flamemag) Pty. Ltd., a wholly owned subsidiary of QMC, and MDL each will hold 50% interest. MDL already is involved in the antimony-base flame retardant market in France.[6] QMC also announced plans to increase its fused magnesia production capacity from 15,000 tons per year to 22,600 tons per year by early 1995.[7]

Devex Ltd. planned to nearly double its caustic-calcined magnesia capacity at Young, New South Wales, by installing a kiln from its closed Fifield facility. After kiln installation, the company's total annual caustic-calcined production capacity was estimated to be between 17,000 and 20,000 tons.[8]

China.—The Chinese Government reportedly instituted a new export licensing system for several minerals including magnesite, beginning April 1, 1994. Under the new system, companies wishing to export these minerals were invited to present bids for export licenses and for export tonnage quotas. The export licenses essentially consisted of a fee paid to export material. Two rounds of bidding were held in 1994, one for the 6-month period of April to September and the second for the next 3-month period. The export licensing system has the effect of raising prices of Chinese materials on the world market.[9]

Israel.—Dead Sea Periclase Ltd. (DSP) and Dead Sea Bromine Group, both of which are part of Israel Chemicals Ltd., announced the formation of a joint venture to develop a new range of $Mg(OH)_2$ flame retardants. A new 6,000-ton-per-year plant began operation at DSP's Mishor Rotem location producing surface-treated $Mg(OH)_2$ flame retardants for use in polymer applications such as polyvinyl chloride, polyethylene, and copolymers for wire and cable.[10] This joint-venture comapny reportedly signed a sales agreement with Kyowa Chemical Industry Co. of Japan to promote the sales of its fire retardants under the Kyowa trademark in Japan, the Republic of Korea, and Taiwan.[11]

South Africa, Republic of.—As part of the Government's effort to reduce unemployment, generate income, and replace imports, Venmag began operating a small-scale magnesite mine in Transvaal. The plant, established with the assistance of Mintek, began operating in late 1993, but was officially commissioned in March 1994. Initial plant capacity was 300 tons per month of caustic-calcined magnesia and 120 tons per month of crude magnesite. Crude magnesite production capacity was being increased to 500 tons per month to meet domestic demand in the chemical and fertilizer markets. The caustic-calcined magnesia was being marketed to water treatment, fertilizer, and pharmaceutical applications. Venmag also planned to start production of a wall covering material from magnesite fines to supply the local construction market.[12] *(See tables 9 and 10.)*

Outlook

Magnesium compounds consumption was expected to remain relatively constant over the next few years. Refractory magnesia demand, the bulk of total U.S. demand, was expected to decrease slightly, but this decrease would be offset by an increase in environmental applications of $Mg(OH_2)$. Even with the additional cost of the export licensing requirements, magnesia from China was expected to continue to supply a significant portion of U.S. demand.

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[1] Chemical Week. V. 154, No. 7, Feb. 23, 1994, p. 43.

[2] Industrial Minerals (London). No. 326, Nov. 1994, pp. 13-14.

[3] ———. No. 322, July 1994, pp. 13-14.

[4] ———. No. 321, June 1994, p. 15.

[5] O'Driscoll, M. Caustic Magnesia Markets. Ind. Miner. (London), No. 318, Mar. 1994, pp. 23-45.

[6] Industrial Minerals (London). No. 320, May 1994, p. 13.

[7] Mining Journal (London). V. 323, No. 8285, July 22, 1994, p. 57.

[8] Page 8 of work cited in footnote 5.

[9] Industrial Minerals (London). No. 325, Oct. 1994, p. 9.

[10] ———. No. 316, Jan. 1994, p. 13.

[11] ———. No. 323, Aug. 1994, p. 13.

[12] ———. No. 324, Sept. 1994, p. 23.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Magnesium Compounds. Ch. in Mineral Commodity Summaries, annual.

Other Sources

Industrial Minerals (London), monthly.

Roskill Information Services Ltd. Magnesium Compounds 1992, 7th ed.

Roskill Information Services Ltd. Olivine 1990, 2d ed.

TABLE 1
SALIENT MAGNESIUM COMPOUND STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Caustic-calcined and specified magnesias: 2/					
Shipped by producers: 3/					
Quantity	135	154	130	131	135
Value	$37,900	$48,100	$36,800	$39,500	$39,300
Exports, quantity 4/	2	4	5	4	3
Imports for consumption, quantity 4/	84	108	83	141	125
Refractory magnesia:					
Shipped by producers: 3/					
Quantity	335	296	291	268	243
Value	$95,000	$85,300	$80,800	$77,700	$67,800
Exports, quantity	59	66	57	60	60
Imports for consumption, quantity	155	147	210	279	342
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	342	308	302	315	300
Value	$27,000	$25,700	$25,200	$26,200	$25,000
World production (magnesite)	10,500 r/	9,790 r/	9,990 r/	8,310 r/	8,520 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Excludes caustic-calcined magnesia used in the production of refractory magnesia.

3/ Includes magnesia used by producers.

4/ Caustic-calcined magnesia only.

TABLE 2
U.S. MAGNESIUM COMPOUND PRODUCERS, BY RAW MATERIAL SOURCE, LOCATION, AND PRODUCTION CAPACITY, IN 1994

Raw material source and producing company	Location	Capacity (metric tons of MgO equivalent)	Products
Magnesite: Premier Services Inc.	Gabbs, NV	100,000	Caustic-calcined and dead-burned magnesia.
Lake brines:			
Great Salt Lake Minerals Corp.	Ogden, UT	90,000	Magnesium chloride and magnesium chloride brines.
Reilly Industries Inc.	Wendover, UT	45,000	Magnesium chloride brines.
Well brines:			
The Dow Chemical Co.	Ludington, MI	214,000	Magnesium hydroxide.
Martin Marietta Magnesia Specialties Inc.	Manistee, MI	275,000	Caustic-calcined and dead-burned magnesia.
Morton International	do.	10,000	Magnesium carbonate, magnesium hydroxide, and caustic-calcined magnesia.
Seawater:			
Barcroft Co.	Lewes, DE	5,000	Magnesium hydroxide.
The Dow Chemical Co.	Freeport, TX	20,000	Magnesium chloride.
National Refractories & Minerals Corp.	Moss Landing, CA	165,000	Magnesium hydroxide and caustic-calcined and dead-burned magnesia.
Premier Services Inc.	Port St. Joe, FL	50,000	Caustic-calcined and dead-burned magnesia.
Total		974,000	

TABLE 3
U.S. MAGNESIUM COMPOUNDS SHIPPED AND USED 1/

	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Caustic-calcined 2/ and specified (USP and technical) magnesias	131,000	$39,500	135,000	$39,300
Magnesium hydroxide [100% Mg(OH) 2] 2/	252,000	61,600	240,000	65,700
Magnesium sulfate (anhydrous and hydrous)	42,700	14,000	44,600	15,100
Precipitated magnesium carbonate 2/	3,010	672	2,470	534
Refractory magnesia	268,000	77,700	243,000	67,800

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

TABLE 4
YEAREND MAGNESIUM COMPOUND PRICES

Material		Price
Magnesia, natural, technical, heavy, 85%, f.o.b. Nevada	per short ton	$232- $265
Magnesia , natural, technical, heavy, 90%, f.o.b. Nevada	do.	265
Magnesia, dead-burned	do.	330
Magnesia, synthetic, technical	do.	366
Magnesium chloride, hydrous, 99%, flake	do.	290
Magnesium carbonate, light, technical (freight equalized)	per pound	.73- .78
Magnesium sulfate, technical (epsom salts)	do.	.16

Source: Chemical Marketing Reporter.

TABLE 5
U.S. EXPORTS OF CRUDE AND PROCESSED MAGNESITE, BY COUNTRY 1/

Material and country	1993 Quantity (metric tons)	1993 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Caustic-calcined magnesia:				
Germany	495	$404	458	$304
Mexico	543	243	574	258
Netherlands	865	573	984	572
Venezuela	1,670	477	146	76
Other	559 r/	762 r/	1,080	573
Total	4,450	2,460	3,240	1,780
Dead-burned and fused magnesia:				
Canada	40,700	14,300	42,100	15,700
Germany	2,160	689	1,140	402
Israel	906	524	1,080	675
Venezuela	10,300	3,770	7,750	2,530
Other	5,770 r/	2,560 r/	7,750	3,520
Total	59,800	21,800	59,800	22,800
Other magnesia:				
Canada	6,510	2,570	5,160	2,130
France	2,660	710	97	119
Mexico	7,380	3,590	927	788
Venezuela	1,350	513	1,660	561
Other	4,110 r/	3,770 r/	4,820	5,060
Total	22,000	11,100	12,700	8,660
Crude magnesite:				
Canada	791	245	1,200	129
China	237	105	730	78
Korea, Republic of	819	231	3,830	410
Mexico	818	321	1,480	159
Netherlands	993	641	143	34
Other	3,730 r/	1,460 r/	1,180	177
Total	7,390	3,010 r/	8,570	987

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF MAGNESIUM COMPOUNDS1/

Material	1993 Quantity (metric tons)	1993 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Magnesium chloride (anhydrous and other)	3,140	$2,640	4,400	$2,520
Magnesium hydroxide and peroxide	2,540	3,580	10,100	5,330
Magnesium sulfate (natural kieserite and epsom salts)	69	52	2,250	365
Magnesium sulfate (other)	4,140	1,670	4,160	2,210

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF CRUDE AND PROCESSED MAGNESITE, BY COUNTRY 1/

Material and country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Caustic-calcined magnesia:				
Canada	42,800	$8,560	41,700	$8,600
China	83,100	4,700	72,500	4,420
Greece	9,880	1,470	6,200	1,290
Other	4,850 r/	986 r/	4,770	1,770
Total	141,000	15,700	125,000	16,100
Dead-burned and fused magnesia:				
Australia	1,330	583	12,000	3,330
Austria	13,600	6,070	21,300	9,660
China	196,000	15,900	264,000	20,900
Israel	16,200	6,880	10,600	5,060
Other	51,700 r/	19,200 r/	34,600	12,900
Total	279,000	48,700	342,000	51,800
Other magnesia:				
China	1,330	238	228	82
Israel	856	1,450	1,310	2,300
Japan	1,830	3,640	1,850	3,540
Mexico	--	--	3,070	1,150
Other	1,110 r/	936 r/	1,430	1,430
Total	5,120	6,270	7,890	8,500
Crude magnesite:				
Austria	--	--	92	33
China	109	43	53	26
Japan	144	167	99	20
Other	79 r/	41 r/	82	54
Total	332	251	326	133

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF MAGNESIUM COMPOUNDS 1/

Material	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Magnesium chloride (anhydrous and other)	5,320	$1,740	23.100	$5,820
Magnesium hydroxide and peroxide	1,770	1,830	2,790	4,700
Magnesium sulfate (natural kieserite)	20,200	1,040	19,600	1,080
Magnesium sulfate (natural epsom salts)	138	154	192	136
Magnesium sulfate (other)	6,650	1,380	9,790	1,940

1/ Previously published data and 1994 are rounded by the U.S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 9
WORLD MAGNESIUM COMPOUNDS ANNUAL PRODUCTION CAPACITY 1/ 2/
DECEMBER 31, 1994

(Thousand metric tons, MgO equivalent)

Country	Raw material				Total
	Magnesite		Seawater or brines		
	Caustic-calcined	Dead-burned	Caustic-calcined	Dead-burned	
North America:					
Canada	100	--	--	--	100
Mexico	--	--	15	145	160
United States	NA	NA	NA	NA	974 3/
Total	100	NA	15	145	1,230
South America: Brazil	45	146	--	--	191
Europe:					
Austria	90	575	--	--	665
France	--	--	30	--	30
Greece	100	140	--	--	240
Ireland	--	--	NA	NA	100
Italy	25	--	5	125	155
Netherlands	--	--	--	100	100
Norway	--	--	25	--	25
Poland	--	10	--	--	10
Russia	--	2,200	--	--	2,200
Serbia and Montenegro	40	200	--	--	240
Slovakia	30	700	--	--	730
Spain	135	70	--	--	205
Turkey	50	224	--	--	274
Ukraine	--	--	20	80	100
United Kingdom	--	--	NA	NA	200
Total	470	4,120	80	305	5,270
Africa:					
Kenya	NA	NA	--	--	170
South Africa, Republic of	9	--	--	--	9
Zimbabwe	NA	NA	--	--	2
Total	9	--	--	--	181
Asia:					
China	200	850	--	10	1,060
India	25	228	--	--	253
Israel	--	--	10	60	70
Japan	--	--	570	65	635
Korea, North	NA	NA	--	--	2,100
Korea, Republic of	--	--	--	50	50
Nepal	--	50	--	--	50
Total	225	1,130	580	185	4,220
Oceania: Australia	167	40	--	--	207
Grand total	1,020	5,430	675	635	11,300

NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes capacity at operating plants as well as at plants on standby basis.

3/ Includes capacity for production of magnesium chloride, magnesium chloride brines, magnesium carbonate, magnesium hydroxide, and caustic-calcined and dead-burned magnesia.

TABLE 10
MAGNESITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Australia e/	60,000	100,000	262,000 r/	261,000 r/	275,000
Austria	1,180,000	961,000	995,000	649,000 r/	600,000
Brazil 3/ (beneficiated)	257,000	242,000	273,000 r/	232,000 r/	250,000
Canada e/ 4/	150,000 5/	180,000	180,000	180,000	180,000
China e/	2,170,000	1,650,000	1,510,000	1,500,000	1,500,000
Colombia	19,300	18,800	18,800	9,820 r/	9,500
Czechoslovakia 6/ 7/	561,000	328,000	XX	XX	XX
Greece	697,000	590,000	250,000 e/	250,000 e/	200,000
India	544,000	539,000 e/	603,000 r/	409,000 r/	500,000
Iran 8/	1,410	29,300	36,200	40,000 e/	40,000
Korea, North e/	1,500,000	1,600,000	1,600,000	1,600,000	1,600,000
Mexico	579	600 r/ e/	--	1,530 r/	1,500
Nepal	-- r/	-- r/	-- r/	-- r/	--
Pakistan	4,270	5,190	6,480	4,160 r/	4,000
Philippines e/	700	700	700	700	700
Poland	23,300	8,100	12,900	13,000 r/	13,000
Russia e/ 9/	XX	XX	1,100,000	800,000	600,000
Serbia and Montenegro 10/	XX	XX	185,000	55,000 r/	68,000 5/
Slovakia 6/	XX	XX	1,270,000	1,200,000 e/	1,200,000
South Africa, Republic of	114,000	92,600	60,100	67,400 r/	69,700 5/
Spain e/	444,000 5/	445,000	400,000	400,000	400,000
Turkey (run of mine)	845,000	1,370,000	1,220,000	629,000 r/	1,000,000
U.S.S.R. e/ 9/ 11/	1,600,000	1,400,000	XX	XX	XX
United States	W	W	W	W	W
Yugoslavia 10/ 12/	252,000	210,000	XX	XX	XX
Zimbabwe	32,600	23,300	8,970	6,280 r/	6,000
Total	10,500,000	9,790,000 r/	9,990,000 r/	8,310,000 r/	8,520,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Figures represent crude salable magnesite. In addition to the countries listed, Bulgaria produced magnesite, but output is not reported quantitatively, and available information is inadequate for formulation of reliable estimates of output levels. Table includes data available through May 19, 1995.

3/ Series reflects output of marketable concentrates. Production of crude ore was as follows, in metric tons: 1990--1,430,000; 1991--879,000; 1992--1,000,000 (revised); 1993--974,000 (revised); and 1994--1,000,000 (estimated).

4/ Magnesitic dolomite and brucite. Figures are estimated on the basis of reported tonnage dollar value.

5/ Reported figure.

6/ All production in Czechoslovakia from 1990-92 came from Slovakia.

7/ Dissolved on Dec. 31, 1992.

8/ Year beginning Mar. 21 of that stated. Figures for 1990 are for magnesite; figures for 1991 and 1992 include 3,340 tons and 220 tons of huntite ($Mg_3Ca(CO_3)_4$), white clay, respectively.

9/ All production in U.S.S.R. for 1990 and 1991 came from Russia.

10/ All production in Yugoslavia for 1990 and 1991 came from Serbia and Montenegro.

11/ Dissolved in Dec. 1991.

12/ Dissolved in Apr. 1992.

MANGANESE

By Thomas S. Jones

Manganese (Mn) is essential to iron and steel production by virtue of its sulfur-fixing, deoxidizing, and alloying properties. Currently, no practical approaches exist for replacing it by other materials or for obtaining the bulk of U.S. requirements from domestic sources. Ironmaking and steelmaking have accounted for most domestic manganese demand, presently in the range of 85% to 90% of the total. Among a variety of other uses, manganese is a key component of certain widely used aluminum alloys and is used in oxide form in dry cell batteries. The overall level and nature of manganese use in the United States is expected to remain much the same in the near and medium term.

According to reported data, the rates of consumption of manganese as ore in ironmaking and as ferroalloys and metal in steelmaking declined in 1994 compared with those in 1993. The marginal drop of about 1% for the rate in steelmaking continued to be because of a lower usage rate for ferromanganese.

Further growth of manganese consumption in batteries was denoted by the expansion on schedule of domestic capacity for production of electrolytic manganese dioxide (EMD) as well as by the setting of another new record high for imports of manganese dioxide.

In manganese U.S. foreign trade in 1994, ore was a relatively more important component of imports than in recent prior years. Non-traditional sources contributed to silicomanganese imports. The silicomanganese trade dispute finally culminated in December in imposition of antidumping duties or restrictions on material from Brazil, China, and Ukraine. Imposition of antidumping duties on silicomanganese by the European Union, also in December, meant that such duties had become effective in all major steel producing areas of the Western World. In the United States, additional allegations of unfair trading practices arose late in the year for manganese metal and manganese sulfate from China.

Price movements varied for the main manganese materials. The price for metallurgical-grade manganese ore delivered to U.S. customers decreased for the fourth consecutive year, by a smaller extent than in 1993. Averaged over the year, the price in the U.S. market for high-carbon ferromanganese was virtually unchanged while that for silicomanganese increased about 7%.

The rate slowed for disposal of manganese materials from Government stockpiles. The Government still held inventories of manganese, all forms, that were equivalent to more than 2 years of apparent consumption.

World production of manganese ore was estimated to have totaled about the same as in 1993. *(See table 1.)* New or rejuvenated production of ore was underway in Western Australia, at a second mine in the Carajás area of northern Brazil, and in Namibia.

Most data in this report are rounded by the U.S. Bureau of Mines to three significant digits. Table footnotes will indicate which statistics have been rounded.

Legislation and Government Programs

Stockpile.—Effective April 22, the Defense Logistics Agency (DLA) revised the Fiscal Year 1994 Annual Materials Plan such that the maximum fiscal year 1994 disposal authority for metallurgical-grade manganese ore was raised to 363,000 tons from 227,000 tons, while that for high-carbon ferromanganese was reduced to zero from 45,400 tons. Maximum disposal authority remained the same for chemical-grade ore and natural battery-grade ore, 45,400 tons and 54,400 tons, respectively.

On September 28, DLA announced that in accordance with the Fiscal Year 1995 Annual Materials Plan the maximum quantities of manganese stockpile materials to be offered for sale during fiscal year 1995 included, in tons, chemical-grade ore, 36,300; natural battery-grade ore, 54,400; metallurgical-grade ore, 67,100; and electrolytic manganese metal, 1,810.

Disposals of manganese materials in 1994 announced by DLA totaled, in tons, natural battery-grade ore, 6,140; metallurgical-grade ore, 73,300; high-carbon ferromanganese, 15,000; and medium-carbon ferromanganese, 4,230. Disposals of ore were cash whereas those of ferromanganese were payment-in-kind. Metals Refining Co., Orem, UT, was placed in default for the 5-year contract made in October 1993 that called for removal of 145,000 tons of metallurgical-grade ore during fiscal year 1994.

Data reported by DLA indicated that changes in physical inventory of manganese materials in 1994 all were decreases and consisted of, in tons, natural battery-grade ore, 23,900; chemical-grade ore, 1,640; metallurgical-grade ore, 108,000; high-carbon ferromanganese, 4,810; medium-carbon ferromanganese, 3,910; and silicomanganese, 25. At yearend, the estimated manganese content of the manganese inventories being held by the Government was 1.5 million tons. *(See table 2.)* This was about 4.4% less than at the end of 1993 but still more than twice the current national apparent consumption.

Other.—Citing potential public health risks, the Environmental Protection Agency (EPA) announced on July 13 that it would still not grant a waiver to Ethyl Corp. that would permit use of methylcyclopentadienyl manganese tricarbonyl (MMT, "HiTEC 3000") as an octane-enhancing additive in unleaded gasoline (59 FR 42227-42261). Ethyl immediately filed an appeal of EPA's decision with the U.S. Court of Appeals for the District of Columbia Circuit. This appeal had not been acted upon by the end of 1994. In the course of this most recent consideration of Ethyl's petition, EPA revised the reference concentration (RfC) for inhaled manganese to a much lower value than had been in effect as of 1990--0.05 micrograms per cubic meter in place of the former value of 0.4 micrograms per cubic meter. Ethyl published its findings indicating that manganese oxides produced from use of MMT do not adversely affect the performance of automotive catalytic converters.[1] Also, Canadian workers and Ethyl published the results of a number of studies relating to atmospheric emissions of manganese resulting from use of MMT in Canada, where MMT has replaced lead in gasoline since the late 1970's.[2]

Deep Seabed Mining Exploration License USA-4 was surrendered to the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce (DOC), by the Kennecott Consortium on May 21 (58 FR 33933) and reissued by NOAA to Ocean Minerals Co. on December 22 (59 FR 66942), in accordance with provisions of the Deep Seabed Hard Mineral Resources Act.

Production

Ore and Concentrate.—Production and shipments continued to consist only of a small amount of manganiferous material for use in coloring brick. This material was mined in Cherokee County, SC, and had a natural manganese content in the range of 5% to 15%. Shipments data were not published to avoid disclosing proprietary data.

Ferroalloys, Metal, and Synthetic Dioxide.—Production statistics for these materials were not published to avoid disclosing proprietary data. *(See table 3.)* Elkem Metals Co. remained the only domestic producer of manganese ferroalloys, which was at its Marietta, OH, plant. Anticipating the ending of the Government's program of converting manganese ore from the National Defense Stockpile into high-carbon ferromanganese, Elkem Metals was investing about $9 million toward improving the competitiveness of that plant. The investment included upgrading furnaces and refining equipment in order to add low-carbon grades of ferromanganese and silicomanganese to the plant's product mix.

In mid-1994 as scheduled, Kerr-McGee Chemical Corp. completed a 50% increase in annual capacity for EMD of its plant at Henderson, NV. As a result, that plant's EMD capability was raised to 22,200 tons per year.

Consumption, Uses, and Stocks

The data relating to manganese end use plus certain other information indicated that metallurgical applications accounted for most manganese consumption, 85% to 90% of which has been for steelmaking. *(See tables 4 and 5.)* This usage pattern is typical of most industrialized countries.[3] On the basis of the data for reported consumption, unit consumption of manganese in ironmaking, which for 1994 could not be published to avoid disclosing proprietary data, decreased even further. On the same basis, overall manganese unit consumption in steelmaking declined about 1% and followed the continuing downward trend in unit consumption for ferromanganese. *(See table 6.)* Relatively small quantities of manganese were used for alloying with nonferrous metals, chiefly in the aluminum industry as manganese-aluminum briquets containing 75% Mn and 25% Al. A manganese-aluminum additive similar to this conventional briquet but with the manganese content elevated to 85% was undergoing commercial testing.[4]

Comparatively small amounts of manganese were used domestically in animal feed, brick coloring, dry cell batteries, manganese chemicals, and plant fertilizers. These were among the many nonmetallurgical applications of manganese.[5] The source of manganese units for these applications was mainly manganese ore. In Europe, a new chemical application for manganese was short-lived. Unilever PLC initiated and then discontinued use of a manganese catalyst in laundry detergent.[6]

Data on domestic consumption of manganese ore, exclusive of that consumed within the steel industry, were collected by means of the "Manganese Ore and Products" survey. By means of this survey, approximately 15 firms were canvassed that process ore by such methods as grinding and roasting or consume it in the manufacture of manganese ferroalloys, metal, and chemicals. Their collective consumption is believed to represent that of the United States except for negligible quantities consumed by other firms, if any. In 1994, responses were obtained from all firms canvassed. The aggregated consumption data obtained were incorporated into table 4, but for 1994 only the total could be displayed to avoid disclosing proprietary data. Total annual ore consumption increased rather than decreased for the first time since 1989.

Within the battery industry worldwide, production of carbon-zinc dry cell batteries, which predominantly was based on use of natural manganese dioxide, continued to hold a sizable lead over that of alkaline cells, which employed electrolytic manganese dioxide. Alkaline cells again had a high growth component, with U.S. output advancing 10% in volume compared with that in 1993. A potential future new market for manganese in batteries could come from the current emphasis on achieving an electric vehicle (EV) as an alternative to gasoline-powered automobiles. The United States Advanced Battery Consortium contracted with a joint venture between Duracell Intl. Inc. and Germany's Varta Batterie AG for development of a rechargeable EV battery system based on lithium-ion technology involving manganese oxide.

The motivation for recycling and/or recovery of materials from dry cell batteries shifted from concern about mercury content, which can be projected to vanish in the future, to strictly disposal and landfill issues. One option being investigated on a cooperative basis between European, Japanese, and U.S. organizations was the relatively low cost approach of recycling via existing commercial metals facilities. In the United States, the Eveready Battery Co. entered into an agreement with Drinkard Metalox Inc. of Charlotte, NC, for development of a solution process to recover metals such as manganese and zinc from primary household batteries. The technology to be developed was expected to operate at low temperatures with relatively small energy consumption.

Prices

For 1994, with the price of manganese in metallurgical-grade ore taken as 1.0, the corresponding approximate prices per manganese unit were 2.5 for high-carbon ferromanganese and silicomanganese, 4.3 for medium-carbon ferromanganese, and 9.6 for manganese metal. These price factors are based on year-average prices such as discussed in the following.

Manganese Ore.—The U.S. price of metallurgical-grade manganese ore decreased for the fourth year in succession. A mid-range value for the average price, c.i.f. U.S. ports, of metallurgical-grade ore containing 48% manganese was assessed as $2.40 per metric ton unit (mtu). It is recognized that prices $0.10 per mtu or more above or below this value applied, depending on ore quality, time of year, and nature of the transaction. Because the mtu is 1% of a metric ton, i.e., 10 kilograms of contained manganese, the price of manganese in ore in 1994 and 1993 can be expressed in cents per kilogram as 24.0 and 26.0, respectively. The percentage decrease in ore price for 1994 approached 8%, and was less than one-half that of 1993.

The price evolution in metallurgical-grade ore for the United States in 1994 approximately paralleled that in other international markets, as typified by contracts between Japanese consumers and Australian and South African suppliers for deliveries in the contract year ending March 31, 1995. For the benchmark of high-grade lumpy ore containing 48% manganese, negotiations that concluded in late June between Japanese steel mills and Australia's Broken Hill Pty. Co. Ltd. (BHP) resulted in a f.o.b. price of $2.04 versus $2.25 per mtu for the 1993 contract year. Shortly thereafter, Japan's South African ore suppliers agreed to a 9.3% decrease in f.o.b. price for lumpy ore, from $2.15 to $1.95 per mtu.

The price of a metric ton of ore is obtained by multiplying the mtu price by the percentage manganese content of the ore. The ore market consists of a number of submarkets because of differences between ores according to the various end uses, such as ferroalloy production, blast furnace ironmaking, and battery manufacture.

Manganese Ferroalloys.—Price information was based on quotations for imported material, as no current price data were publicly available for domestic product. Prices at yearend were lower than at the beginning of 1994, by 2% for high-carbon ferromanganese and about 5% for silicomanganese. The year-average price for high-carbon ferromanganese was 0.7% less than that for 1993, whereas for silicomanganese the year-average price increased by more than 7%. English units continued to be the basis for price quotes in the United States as given in sources such as Platt's Metals Week.

The price range for high-carbon ferromanganese containing 78% manganese, f.o.b. Pittsburgh or Chicago warehouse, which began 1994 at $490 to $500, shifted downward $10 in mid-April and again in late June. The resulting range of $470 to $480 remained in effect until the last two weeks of the year, when adjustments were made that resulted in a broader final range of $470 to $500.

For silicomanganese, the trend in price level was downward until mid-October, when a recovery took place to about the general level that applied during the spring and summer. In January, the price range for imported silicomanganese with 2% carbon was 26 to 26.5 cents per pound of alloy, f.o.b. Pittsburgh or Chicago warehouse. A low of 24 to 25 cents reached the first week of October was followed by slightly higher quotes such that a final range of 24.5 to 25.5 cents was in effect by December.

Manganese Metal.—Trade journals continued to carry throughout the year only the same per pound prices already published effective mid-November 1990, which were for bulk shipments of domestic material, f.o.b. shipping point: a range of $1.04 to $1.05 according to Metals Week and $1.05 according to American Metal Market. However, in a mid-November report on the antidumping suit for manganese metal, Metals Week indicated that industry sources placed the then-current price range at 80 to 90 cents for domestic and South African metal and 70 to 76 cents for Chinese metal.

Foreign Trade

In terms of estimated manganese content, the total number of manganese units traded decreased about 20% for exports and increased about 3% for imports. For export categories, decreases were the rule; metal was an exception. *(See table 7.)* For import categories, receipts were up significantly for ore (especially from Gabon) and such higher value materials as low- and medium-carbon ferromanganese, unwrought metal, and manganese dioxide, but down for high-carbon ferromanganese and silicomanganese. *(See table 8.)* On the basis of content, the ratio of the sum of ferroalloy plus metal imported to the corresponding sum for ore plus dioxide was 2.6, the lowest such ratio since 1989.

Among exports, the modestly decreased quantity of ore was, as for 1992-93, among the least for the past two decades. The sizable drop in exports of ferromanganese was more pronounced for material with a carbon content of more than 2% (-48%) than for other ferromanganese (-32%). Reexports of ore, ferromanganese, and silicomanganese were all to Canada, and, in tons, were 426, 2,850, and 3,630, respectively. Of the 158 tons of metal reexported, 121 tons were shipped to Canada.

Among imports, the average manganese content was 48.7% for ore, which was the least since 1990, and 78.8% for ferromanganese, which was the greatest since 1972. The comparatively high average content for ferromanganese resulted from increased volumes for the refined grades, as the import volume for medium-carbon ferromanganese was second only to that for 1988.

For silicomanganese, import volume decreased while still reaching a total second only to that in 1993, and sources proliferated. Receipts of silicomanganese from India and Romania were the first manganese materials from those countries since 1982 and 1984, respectively. Imports from the Republic of South Africa rose 80% to a record level. Reported imports of spiegeleisen were 162 tons, which was about one-third less than for the previous year; all were from Germany at a high unit value.

For imports of metal, the 61% increase in volume for unwrought material produced a new record for that category. The Chinese share of metal imports continued to advance to 24% of the combined total.

Among imports of manganese chemicals, those of manganese dioxide easily surpassed 1993's record quantity. Those from Australia rose, as has been the case every year since the beginning of shipments from that country in 1991. All dioxide imports appeared to have been synthetic material except for 20 tons reported from Canada at low unit value. Of imports under the classification "Other sulfates," which includes manganese sulfate, those from China decreased by about 23% to 4,010 tons at a value of $942,000 and those from Mexico by about 13% to 10,100 tons at a value of $5.62 million.

The terms of foreign trade with the United States were liberalized for a number of countries. Under the Generalized System of Preferences (GSP) program, duty-free status, as applicable, was granted in 1994 (effective date in parenthesis) to U.S. imports from Kazakhstan (March 4, 59 FR 8115), Romania (March 4, 59 FR 8115), the Republic of South Africa (May 10, 59 FR 19629), and Ukraine (March 23, 59 FR 10725). Late in the year, Congress retroactively extended until July 31, 1995, the GSP program itself. Technically as of October 1, for the second consecutive year, the program had been allowed to lapse.

Imports from China of chemical or metallurgical materials containing manganese were involved in several trade disputes. In the case of potassium permanganate, the International Trade Administration (ITA) of the U.S. Department of Commerce (DOC) established in May a country-wide dumping margin of 128.94% for material from China, thus eliminating the possibility of some shipments at a margin of about 40%. This was the final result of ITA's administrative review for 1990 (59 FR 26625-26630). On November 8, Elkem Metals, Pittsburgh, PA, and Kerr-McGee Chemical, Oklahoma City, OK, filed petitions with ITA and the U.S. International Trade Commission (ITC) alleging less than fair value (LTFV) imports of manganese metal from China. On December 20, ITC announced an affirmative decision (60 FR 146), with the consequence that ITA's antidumping investigation would continue. On November 30, American MicroTrace Corp., Virginia Beach, VA, filed petitions with ITA and ITC alleging LTFV imports of manganese sulfate from China.

In December, approximately 13 months after Elkem Metals and the Oil, Chemical and Atomic Workers, Local 3-639, Belpre, OH, had filed petitions with ITA and ITC alleging LTFV imports of silicomanganese from Brazil, China, Ukraine, and Venezuela, ITC made affirmative final determinations of such imports for Brazil, China, and Ukraine but not Venezuela (59 FR 65788). As one result, ITA issued antidumping orders on imports of silicomanganese from Brazil and China that specified cash deposit margins for material from Brazil as 64.93% for Cia. Paulista de Ferro-Ligas and 17.60% for all other Brazilian producers and for material from China as 150.00%. Secondly, for imports of silicomanganese from Ukraine, the restraint agreement that DOC had worked out with Ukraine as of October 31 (FR 59 60951-60958) became effective.

World Review[7]

Global outputs were estimated to have remained about the same for manganese ore and ferroalloys overall as those in 1993. *(See tables 9 and 10.)*

Australia.—BHP's monthly reports indicated that manganese ore output of BHP's Groote Eylandt Mining Co. Pty. Ltd. (GEMCO) subsidiary totaled about 1,750,000 million tons, an increase of about one-sixth above that for 1993. The total for GEMCO's shipments to foreign and domestic markets from operations in the Northern Territory rose by about 4% to 1,650,000 tons.[8] BHP announced in May that it had purchased a 14% equity interest in Grupo Ferrominero S.A., which controls Cía. Minera Autlán (Autlán), the Mexican producer of manganese ore and ferroalloys. BHP further stated that in accordance with this transaction BHP was to supply Autlán's requirements for imported manganese ore for 5 years. In midyear BHP also announced that its Australian Manganese Co. Pty. Ltd. subsidiary was expanding the production capacity for EMD of its plant near Newcastle, New South Wales, for which GEMCO supplies the ore feed. The plant was to expand 24% to more than 22,000 tons annually at a cost of about $8 million.

Manganese ore production declined in Western Australia. In May, Portman Mining Ltd. shut down its operations in the Woodie Woodie area of the Pilbara Manganese Province. Citing adverse ore price developments, Portman put its project on a care and maintenance basis. In September, Portman became full owner of the project by acquiring the 50% interest formerly held by its joint-venture partners. In contrast with Portman's shutdown, Valiant Consolidated Ltd. was bringing another deposit in the Woodie Woodie area into modest production. Valiant was now the sole participant in a project that targeted a potential annual output of about 150,000 tons for mostly Far Eastern consumers.

Brazil.—At 503,000 tons, shipments of manganese ore by Indústria e Comércia de Minérios S.A. from operations at Serra do Navio, Amapá Territory, reached a total almost identical to that for 1993. Shipments were through Porto de Santana on the Amazon River and consisted of 250,000 tons to customers in Europe, 147,000 tons to South America (including Brazil), 88,600 tons to Asia, and 17,100 tons to North America.[9] The shipments total was about the same as the annual average for the past 5 years.

Production of manganese ore by Cia. Vale do Rio Doce (CVRD) from its Azul Mine in the Carajás region of northeastern Brazil was estimated to have returned to the 700,000-ton level last attained in 1990. In August, CVRD doubled its shareholding in Urucum Mineração S.A. from 46.66% to 93.32%. In 1992-93, Urucum's annual manganese ore production had been in the vicinity of 200,000 tons from a mine near Corumba in Mato Grosso do Sul State. For that area close to the Bolivian border in southwestern Brazil, CVRD was reported to be considering producing iron ore and building a ferromanganese plant.

Mineração Buritirama S.A. was formed as a joint venture to initiate production of manganese ore from Prometal Produtos Metalúrgicos S.A.'s Buritirama Mine in Pará State near CVRD's Azul Mine. Along with Prometal as majority shareholder, other participants in the venture were Brazil's Silex Trading Co. and Finland's Outokumpu Engineering Contractors. Production of medium-grade ore with a manganese content of about 45% and a relatively low phosphorus content was projected to start up at about 100,000 tons per year. The project was visualized to lead to annual production of concentrates in the range of 500,000 tons, of which 40% would be lump and 60% would serve as feed for a sinter plant that was expected to begin operating in 1996.

China.—Imports of manganese ore were reported to have increased by two-thirds to 950,000 tons. However, this appeared to exceed probable imports by 200,000 tons in comparison with estimates of ore contracts that now placed the Republic of South Africa as third largest supplier after Australia and Gabon.[10]

Formation of joint ventures that involved smelting manganese ferroalloys in China was reported. Asia Minerals Investment Ltd., which was based in Hong Kong, took a share of about 25% in Emei Shan Asia Ferroalloy Co. Ltd., which was formed with Emei Ferroalloy Factory, Sichuan Province, and Liaoyang AML Ferroalloy Ltd., which was formed with Liaoyang Ferroalloy Factory, Liaoning Province. In each case, the Chinese ferroalloy producer assumed the remaining share of the joint venture and also a minority shareholding position in Asia Minerals. Japan's Itochu Corp., a trading company, and South Africa's Samancor Ltd. formed Hong Kong-based Universal Ore & Alloy Ltd. with the objective of smelting South African ore into ferromanganese in China. Itochu and Samancor were equal partners in this venture that would market the ferromanganese in China and other Asian countries.

In 1993, China's exports of manganese metal were more than 17% greater than those in 1992. The majority of the 1993 shipments went again to Japan and the Netherlands.

European Union.—Late in December the European Commission (EC) imposed antidumping duties on silicomanganese imported into member countries, which for the respective supplying countries were Brazil, 40.6%; the Republic of South Africa, 57.8% (45.3% for material from Transalloys Div. of Highveld Steel & Vanadium Corp. Ltd.); Russia, 57.4%; and Ukraine, 52.8%. This action was in response to a petition filed in the first part of 1993 by Euroalliages, an association of European ferroalloy producers formed also in 1993.

In November, the EC imposed an antidumping duty of 1.26 ECU per kilogram on potassium permanganate from China. This was in response to complaints from producers of permanganate in Germany and Spain.

France.—Complex internal shareholding problems caused Société du Ferromanganèse de Paris-Outreau (SFPO) to file the French equivalent of a Chapter 11 bankruptcy petition in April. In November, a French commercial court accepted the rescue plan of Compagnie Minière de l'Ogooué S.A. (COMILOG), then a relatively small shareholder in SFPO. Under this plan, the realigned ownership of SFPO became COMILOG, 47%; Société Nationale d'Investissement du Gabon, 35%; Italian interests, 9%; and Japanese and South African interests, 5% each. These developments did not lead to shutdowns of SFPO's plants for ferromanganese at Boulogne and silicomanganese at Dunkirk.

Gabon.—Exports of manganese ore from COMILOG's Moanda Mine totaled 1,370,000 tons, of which 1,290,000 tons was metallurgical-grade ore and 73,000 tons was battery-grade ore. Shipments were made via the Port of Owendo in 65 cargoes.[11] Compared with 1993 exports of 1,430,000 tons of metallurgical-grade ore and 32,000 tons of battery-grade, those in 1994 represented changes of about -9.5% and +128% respectively and a decrease overall of 6.4%.

Ghana.—Ghana National Manganese Corp. exported 245,000 tons of ore produced at its Nsuta Mine. The ore was shipped in 24 cargoes from the Port of Takoradi.[12] This volume of shipments was 20% less than that in 1993 and the least since 1987. The history of the mine and its geology and current operating practices were given in a recent review.[13]

Japan.—Imports of metallurgical-grade manganese ore declined about 7% to 1,123,000 tons. For ore containing more than 39% manganese, imports totaled less than 1 million tons for the third successive year and again were mainly from Australia and the Republic of South Africa. For ore containing no more than 39% manganese, imports were mainly from India and the Republic of South Africa. Imports of ferruginous manganese ore decreased by about one-half to 68,000 tons, all but 60 tons of which came from India.

Overall production of manganese ferroalloys decreased by roughly 9% to the lowest total since 1966. The drop was principally because of a 16% decline in production of high-carbon ferromanganese to 246,000 tons. Conversely, production increased for low-carbon ferromanganese and silicomanganese, with the percentage increases exceeding 5% and 6%, respectively.

Imports of manganese ferroalloys increased about 9% to 290,000 tons overall. Imports of silicomanganese decreased about 3% to 204,000 tons whereas total imports of 86,000 tons of ferromanganese were more than twice as great as the 1993 total. The increase in ferromanganese imports was mostly of the high-carbon grade, for which imports rose to 82,000 tons. Trade journal reports indicated that a factor in the rise in imports of high-carbon ferromanganese was the need to replace domestically produced high-carbon material that was being converted into medium- and/or low-carbon grades for export.

Exports of manganese ferroalloys more than doubled to a total of 23,600 tons. By far the largest portion of the total was ferromanganese containing less than 2% carbon, which advanced to 22,800 tons. Japanese statistics indicated that the main reason for this increase was a rise to 13,600 tons in shipments to the United States.

Production and exports of EMD declined somewhat, for production by about 3% to 54,600 tons and for exports 6% to 31,500 tons. Output was reduced at Mitsui Mining & Smelting Co. Ltd.'s Takehara plant, Hiroshima Prefecture, because of a fire on May 31.

Imports of unwrought manganese metal, which included scrap, increased by about 14% to 28,000 tons and thus continued the progression of recent years. China (64%) again led the Republic of South Africa (30%) as a source country.

Mexico.—Overall output of ore products from the operations of Autlán in the Molango District of Hidalgo State decreased by more than 15%. Production data for 1994 in tons and percentage changes from 1993 (in parenthesis) were carbonate ore sold, 73,000 (+13%); oxide nodules, 217,000 (-22%); and, from the Nonoalco Mine, battery ore, 17,000 (-15%). Battery ore production was the smallest in at least the past decade. Autlán experienced a moderate overall increase in output of manganese ferroalloys. Salable production rose about 16% for silicomanganese and declined about 11%, to 36,000 tons, for high-carbon ferromanganese. As stated in more detail under Australia, Australia's BHP acquired a 14% interest in Grupo Ferrominero S.A., which controls Autlán.

Namibia.—Manganese mining was resumed after a lapse of about 30 years at the Otjosondu Mine in central Namibia. Purity Manganese (Namibia) Ltd. began production at this previously worked site in the latter part of the year. The operation consisted of surface mining followed by crushing, screening, and jigging. Annual production of a medium-grade ore, having a manganese content of about 45% and a relatively low phosphorus content of 0.035%, was projected to be in the vicinity of 100,000 tons. Export was to be via the port of Walvis Bay on the west central coast, a distance of 400 km from the mine.[14]

South Africa, Republic of.—According to preliminary data, more than 98% of production of manganese ore consisted of metallurgical-grade ore; the balance was chemical-grade ore. Output of metallurgical-grade ore was 16% greater than that in 1993. The main production categories for metallurgical-grade ore were ore containing 30% to 40% manganese and ore containing more than 48% manganese. These two categories accounted for 35% and 54% of the metallurgical-grade subtotal, respectively, and for each the quantities produced were significantly greater than those in 1993.

South Africa's main manganese ore producers, Associated Manganese Mines of South Africa Ltd. and Samancor, were actively exploring marketing arrangements for their ores in China, possibly also to include ore-to-ferroalloy conversions (see China also). Samancor reassessed its methodology for analyzing ore reserves at its Wessels Mine so that demand for its higher-grade products could be met more profitably.[15] The Wessels Mine has been a source of a semiprecious gem-quality manganoan sugilite, the chemical composition and color development of which was investigated recently.[16]

Production of manganese ferroalloys in facilities ordinarily used to make chromium ferroalloys contributed to record high outputs of ferromanganese and manganese ferroalloys overall. At Samancor's Ferrometals plant at Witbank, production at three smaller ferrochromium furnaces was switched to high-carbon ferromanganese. Also at this plant, a campaign of converting high-carbon ferromanganese into medium-carbon ferromanganese was conducted. This was a short-term expedient pending resolution of financial difficulties at SFPO that were delaying implementation of a joint venture with SFPO to produce medium-carbon ferromanganese in France. At the Palmiet Ferrochrome plant at Krugersdorp, Samancor continued the production of silicomanganese begun from two furnaces in 1993.

Ukraine.—Production of manganese ore and concentrates was at the lowest level since the early 1960's, not only because of the general decline in steel production among Ukraine's traditional customers in the former Soviet bloc but also because of shortages of electricity and natural gas. Energy shortages also kept the output of manganese ferroalloys below capacity at the Nikopol' and Zaporozh'ye ferroalloy plants. Large-scale shipment to Japan of silicomanganese from the Nikopol' plant was reported to have taken place from relatively nearby Black Sea ports rather than by the usual method of a long overland haul via the Trans-Siberian Railway to ocean transport from such Far Eastern ports as Nakhodka.

Current Research and Technology

The U.S. Bureau of Mines analyzed material flows in the manganese industry, emphasizing trends in the United States in the 20th century and the details of flows as of about 1990.[17] The manganese industry also was the subject of a chapter in a new edition of a standard reference book on minerals.[18]

Industrial exposure of workers to manganese and associated health concerns was the subject of investigations by U.S. Government agencies. One dealt with exposures during welding[19] and the other with the possibility that manganese could be a hazard in plywood manufacture.[20]

Variations in practices of foreign steelmakers for control of manganese content were described. In the Republic of Korea, high carbon steels with relatively high manganese contents were being produced using a low-slag practice for dephosphorization in conjunction with a manganese ore addition.[21] In the Netherlands, selective use of iron ores to minimize manganese input and higher slag volumes in steelmaking were used to achieve manganese contents of 0.1% or less in so-called interstitial free steel.[22]

Investigations related to potential methods of improving the manufacturing or properties of manganese ferroalloys included study of counter-current technology for producing low-carbon ferromanganese[23] and means to lower the phosphorus content of manganese ferroalloys, by barium-containing compounds in treating high-carbon ferromanganese[24] and by metallic calcium in treating silicomanganese.[25]

The results of experiments involving electrolytic manganese metal were reported. These reports described the metal's nitriding behavior[26] and the recovery of aluminum upon use of manganese-aluminum briquets in the aluminum industry.[27]

Manganese-containing systems for which the available thermodynamic information were reviewed and evaluated included the carbon-iron-manganese metal ternary[28] and the $MnO\text{-}SiO_2$ slag binary.[29]

Studies were reported that supported proposed new uses for manganese based on the chemical properties of manganese oxides. One potential development was a humidity sensor in which EMD was a key ingredient,[30] and another was a sorbent embodying natural or synthetic manganese oxide for desulfurizing fuel gases obtained by gasifying coal.[31]

Outlook

The trend of manganese demand, domestically and globally, will continue to follow closely that of steel production. Although some nonmetallurgical components of manganese demand may experience higher growth rates than for steel production, especially batteries, this will have only a minor effect on overall manganese demand.

For the past decade, U.S. apparent consumption of manganese has been within approximately plus or minus 10% of about 640,000 tons of contained manganese. This largely has been a consequence of a similar degree of variation in domestic steel production. Manganese demand, which is presented as apparent consumption in table 1, generally has corresponded to but not traced precisely the level of activity in the steel industry. Differences in the respective year-to-year variations are believed to show the influence of unmeasured changes in stocks of manganese materials, such as those of importers, the effect of which may outweigh changes in demand by steelmakers.

Through the year 2000, the outlook for U.S. steel output is for little or no increase and possibly even a slight decline, judging from forecasts of the International Iron and Steel Institute (IISI) and others that were publicized in 1994. The mid-term trend in domestic steel production may actually turn out to be more favorable, considering that the forecast base is a peak year, the uncertainties in steel foreign trade, and the effect of additional domestic capacity that is planned to come on-stream in the near term. Balancing of the positive and negative indications suggests that U.S. apparent consumption of manganese during the remainder of the 1990's will continue to range not far from 640,000 tons of contained manganese. This outlook also assumes no significant change in manganese unit consumption in steelmaking. Present indications are for no change or perhaps slight further decrease. The majority of U.S. demand for manganese units will be met by imports.

The outlook for world manganese demand during the balance of the 1990's is more positive than that for the United States, as also inferred from forecasts for the steel industry worldwide by IISI and others. IISI has projected an overall annual growth rate of 2.8% for world apparent steel consumption. This projection assumes that growth will be at a relatively higher pace in China (6.7%), other Asian countries except for Japan, Latin America, and Eastern Europe, and at closer to 1% in most other regions. Other forecasts suggest an annual growth rate of about 1.5% for steel production, which implies that world manganese demand can be expected to increase at about that rate.

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TABLE 1
SALIENT MANGANESE STATISTICS 1/

(Thousand metric tons, gross weight)

	1990	1991	1992	1993	1994
United States:					
Manganese ore (35% or more Mn):					
Exports	70	66	13	16	15
Imports for consumption	307	234	247	232	331
Consumption	497	473	438	389	449
Stocks, Dec. 31: Consumers	379	275	276	302	269
Ferromanganese:					
Exports	7	15	13	18	11
Imports for consumption	380	320	304	347	336
Consumption	413	346	339	341	347
Stocks, Dec. 31: Consumers	56	50	28	30	36
Consumption, apparent, manganese 2/	630	598	596	696	NA
Ore price, dollars per metric ton unit, c.i.f. U.S. ports	3.78	3.72	3.25	2.60	2.40
World:					
Production of manganese ore	26,100	22,900	22,400 r/	21,200 r/	20,900 e/

e/ Estimated. NA Not available. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Thousand metric tons, manganese content. Based on estimates of average content for all significant components excepts imports, for which content is reported.

TABLE 2
U.S. GOVERNMENT DISPOSAL AUTHORITIES AND YEAREND INVENTORIES FOR MANGANESE MATERIALS IN 1994 1/

(Metric tons, gross weight)

		Physical inventory, Dec. 31				
		Uncommitted				
Material	Disposal authority	Stockpile grade	Nonstockpile grade	Total	Sold, pending shipment	Grand total
Natural battery ore	128,000	112,000	16,400	128,000	6,490	135,000
Synthetic manganese dioxide	2,730	2,730	--	2,730	--	2,730
Chemical ore	154,000	154,000	81	154,000	--	154,000
Metallurgical ore	1,320,000	919,000	397,000	1,320,000	220,000	1,530,000
High-carbon ferromanganese	778,000	982,000	--	982,000	--	982,000
Medium-carbon ferromanganese	--	19,700	--	19,700	--	19,700
Silicomanganese	--	183	--	183	--	183
Electrolytic metal	12,900	12,900	--	12,900	--	12,900

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 3
DOMESTIC PRODUCERS OF MANGANESE PRODUCTS IN 1994

Company	Plant location	Products 1/				Type of process
		FeMn	SiMn	Mn	MnO2	
Chemetals Inc.	Baltimore, MD	--	--	--	X	Chemical.
Do.	New Johnsonville, TN	--	--	--	X	Electrolytic.
Elkem Metals Co.	Marietta, OH	X	X	X	--	Electric furnace and electrolytic.
Kerr-McGee Chemical Corp.	Hamilton, MS	--	--	X	--	Electrolytic.
Do.	Henderson, NV	--	--	--	X	Do.
Ralston Purina Co.:						
Eveready Battery Co.	Marietta, OH	--	--	--	X	Do.

1/ FeMn, ferromanganese; SiMn, silicomanganese; Mn, manganese metal; MnO2, synthetic manganese dioxide.

TABLE 4
U.S. CONSUMPTION AND INDUSTRY STOCKS OF MANGANESE ORE, 1/ BY USE 2/

(Metric tons, gross weight)

Use	Consumption		Stocks, Dec. 31	
	1993	1994	1993	1994
Manganese alloys and metal	W	W	W	W
Pig iron and steel	17,000	W	13,000	W
Dry cells, chemicals, miscellaneous 3/	W	W	W	W
Total	389,000	449,000	302,000	269,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Containing 35% or more manganese (natural).

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

3/ Natural ore, including that consumed in making synthetic manganese dioxide.

TABLE 5
U.S. CONSUMPTION, BY END USE, AND INDUSTRY STOCKS OF MANGANESE FERROALLOYS AND METAL IN 1994 1/

(Metric tons, gross weight)

End use	Ferromanganese			Silico-manganese	Manganese metal
	High carbon	Medium and low carbon	Total		
Steel:					
Carbon	196,000	78,200	274,000	83,100	3,370
Stainless and heat-resisting	12,800	(2/)	12,800	4,460	1,960
Full alloy	19,300	4,810	24,200	18,500	(2/)
High-strength, low-alloy	19,100	3,460	22,500	6,180	(2/)
Unspecified 3/	388	291	679	425	531
Total steel	247,000	86,800	334,000	113,000	5,850
Cast irons	10,400	492	10,900	605	–
Superalloys	W	W	W	–	122
Alloys (excluding alloy steels and superalloys)	1,340	618	1,960	(4/)	19,300 5/
Miscellaneous and unspecified	W	W	W	(4/)	W
Total consumption	259,000	87,900	347,000	113,000 6/	25,200
Total manganese content 7/	202,000	70,000	272,000	74,700	25,200
Stocks, Dec. 31: consumers and producers	24,100	11,800	35,900	5,840	4,220

W Withheld to avoid disclosing company proprietary data; included in "Alloys (excluding alloy steels and superalloys)."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Withheld to avoid disclosing company proprietary data; included in "Steel: Unspecified."

3/ Includes electrical and tool steel, and items indicated by (2/).

4/ Withheld to avoid disclosing company proprietary data.

5/ Approximately 85% of this combined total was for consumption in aluminum alloys.

6/ Internal evaluation indicates that silicomanganese consumption is considerably understated.

7/ Estimated based on typical percent manganese content.

TABLE 6
U.S. UNIT CONSUMPTION OF MANGANESE IN IRONMAKING AND STEELMAKING 1/

(Kilograms per metric ton of raw steel unless otherwise specified)

Form used	1993	1994
IRONMAKING		
Basis: Production of raw steel, million tons 2/	88.8	91.2
Ore 3/	0.08	W
STEELMAKING		
Basis: Production of raw steel and steel castings, million tons	89.7 r/	92.4 e/
Ore 3/	--	--
Ferromanganese	2.89	2.84
Silicomanganese	0.79	0.80
Manganese metal	0.07	0.06
Total, steelmaking	3.74	3.71

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ As ingots, continuous- or pressure-cast blooms, billets, slabs, etc.

3/ Containing 35% or more manganese.

TABLE 7
U.S. EXPORTS OF MANGANESE ORE, FERROALLOYS, AND METAL, BY COUNTRY 1/

Country	1993		1994	
	Gross weight (metric tons)	F.a.s. value (thousands)	Gross weight (metric tons)	F.a.s. value (thousands)
ORE AND CONCENTRATES WITH 20% OR MORE MANGANESE				
Belgium	--	--	3,020	$242
Canada	8,710	$1,040	7,470	879
Chile	--	--	1,640	131
Korea, Republic of	1,340	159	883	71
Netherlands	2,810	294	1,400	112
Other 2/	3,070	302	892	115
Total	15,900	1,790	15,300	1,550
FERROMANGANESE, ALL GRADES				
Canada	15,900	12,900	9,760	8,280
Mexico	460	433	557	606
United Kingdom	40	72	10	16
Venezuela	237	178	66	60
Other	1,370	1,280	587	505
Total	18,000	14,800	11,000	9,470
SILICOMANGANESE				
Canada	8,900	6,410	6,470	5,260
Mexico	347	213	369	226
Other	172	98	--	--
Total	9,420	6,720	6,840	5,490
METAL, INCLUDING ALLOYS AND WASTE AND SCRAP				
Canada	1,050	2,510	1,750	4,090
Japan	1,010	2,930	1,190	2,000
Netherlands	927	2,030	673	1,470
Taiwan	36	59	308	300
United Kingdom	282	549	399	778
Other 2/	530 r/	1,330 r/	542	1,590
Total	3,840	9,400	4,870	10,200

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Unspecified group of countries differs from that in the 1993 Annual Report.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF MANGANESE ORE, FERROALLOYS, METAL, AND SELECTED CHEMICALS, BY COUNTRY 1/

Country	1993 Gross weight (metric tons)	1993 Manganese content (metric tons)	1993 Customs value (thousands)	1994 Gross weight (metric tons)	1994 Manganese content (metric tons)	1994 Customs value (thousands)
ORE AND CONCENTRATES WITH 20% OR MORE MANGANESE						
All grades						
Australia	58,800	30,200	$5,830	44,400	23,200	$3,870
Brazil	11,900	5,570	941	16,800	4,530	268
Canada	--	--	--	9	4	2
Gabon	131,000	66,700	15,300	219,000	112,000	22,200
Mexico	17,800	7,320	1,810	34,700	13,700	2,250
Morocco	83	43 2/	25	108	56 2/	32
South Africa, Republic of	12,000	6,010	978	15,500	7,780	1,150
Total	232,000	116,000	24,900	331,000	161,000	29,800
More than 20% but less than 47% manganese						
Brazil	8,000	3,690	664	16,800	4,530	268
Canada	--	--	--	9	4	2
Mexico	17,800	7,320	1,810	33,300	13,000	2,010
Total	25,800	11,000	2,470	50,000	17,600	2,280
47% or more manganese						
Australia	58,800	30,200	5,830	44,400	23,200	3,870
Brazil	3,930	1,890	277	--	--	--
Gabon	131,000	66,700	15,300	219,000	112,000	22,200
Mexico	--	--	--	1,460	688	245
Morocco	83	43 2/	25	108	56 2/	32
South Africa, Republic of	12,000	6,010	978	15,500	7,780	1,150
Total	206,000	105,000	22,500	280,000	143,000	27,500
FERROMANGANESE						
All grades						
Australia	23,500	18,100	8,670	14,400	10,600	4,520
Brazil	43,900	33,700	18,900	39,500	30,400	19,100
France	77,200	60,200	35,300	88,000	69,100	37,100
Italy	6,920	6,270	9,700	7,270	6,590	10,600
Japan	6,530	5,230	4,740	13,600	11,000	9,860
Mexico	26,700	20,500	16,800	25,900	20,500	16,900
Norway	3,710	3,010	2,920	12,600	10,300	8,760
Russia	10,800	7,780	3,070	374	251	85
South Africa, Republic of	134,000	105,000	60,100	132,000	104,000	60,200
Other 3/	14,600 r/	11,100 r/	7,350 r/	2,350	1,890	1,850
Total	347,000	271,000	168,000	336,000	265,000	169,000
1% or less carbon						
China	700	560	557	--	--	--
France	1,040	921	1,570	168	142	229
Italy	6,920	6,270	9,700	7,270	6,590	10,600
Japan	32	27	66	3,280	2,700	2,340
Norway	708	558	740	357	298	430
South Africa, Republic of	20	17	41	1,010	930	1,600
Other	318	278	418	112	92	185
Total	9,730	8,630	13,100	12,200	10,800	15,400
More than 1% to 2% or less carbon						
Brazil	5,110	4,100	4,260	8,880	7,090	7,020
France	3,790	3,110	3,180	1,200	986	896
Germany	4,750	3,910	3,750	1,000	819	739
Japan	6,500	5,200	4,670	10,300	8,270	7,510
Mexico	22,200	17,600	15,700	24,300	19,400	16,400
Norway	3,000	2,450	2,180	12,300	9,960	8,330
South Africa, Republic of	10,800	8,760	8,540	15,200	12,300	11,600
Other	65	52	46	1,290	1,030	1,030
Total	56,200	45,200	42,300	74,400	59,900	53,500

See footnotes at end of table.

TABLE 8--Continued
U.S. IMPORTS FOR CONSUMPTION OF MANGANESE ORE, FERROALLOYS, METAL, AND SELECTED CHEMICALS, BY COUNTRY 1/

Country	1993			1994		
	Gross weight (metric tons)	Manganese content (metric tons)	Customs value (thousands)	Gross weight (metric tons)	Manganese content (metric tons)	Customs value (thousands)
			More than 4% carbon			
Australia	23,500	18,100	$8,670	14,400	10,600	$4,520
Brazil	38,800	29,600	14,700	30,500	23,300	11,900
France	72,400	56,100	30,500	86,600	68,000	35,900
Russia	10,800	7,780	3,070	374	251	85
South Africa, Republic of	123,000	96,300	51,500	116,000	90,800	47,000
Other 3/	13,300 r/	9,230 r/	3,710 r/	1,600	1,110	420
Total	281,000	217,000	112,000	249,000	194,000	99,900
			SILICOMANGANESE			
Australia	26,700	17,600	10,200	34,000	22,400	14,500
Brazil	64,800	42,100	26,300	21,400	13,900	9,900
China	51,200	33,500	20,500	15,500	10,200	6,590
Croatia	7,550	4,910	3,200	9,950	6,470	4,590
France	13,700	9,030	5,890	8,200	5,420	3,930
India	--	--	--	26,900	18,500	12,300
Mexico	23,000	14,800	9,880	18,200	11,600	8,520
Norway	6,520	4,100	5,600	5,150	3,130	4,330
South Africa, Republic of	57,600	37,900	26,400	104,000	69,000	45,300
Ukraine	37,600	26,500	13,700	14,000	9,300	5,480
Venezuela	14,000	9,070	5,340	7,630	5,040	3,560
Other 3/	13,400 r/	8,690 r/	6,530 r/	8,330	5,480	4,360
Total	316,000	208,000	133,000	273,000	181,000	123,000
			METAL			
Unwrought:						
China	2,500	XX	3,190	3,370	XX	4,060
South Africa, Republic of	7,630	XX	11,200	12,100	XX	17,700
Other	228	XX	431	1,110	XX	1,300
Total	10,400	XX	14,800	16,600	XX	23,000
Other:						
China	220	XX	258	1,500	XX	1,760
South Africa, Republic of	4,300	XX	6,630	1,920	XX	2,940
Other	93 r/	XX	675 r/	208	XX	1,060
Total	4,620	XX	7,560	3,630	XX	5,760
Waste and scrap:						
Canada	112	XX	32	44	XX	38
Other	42	XX	53	17	XX	25
			MANGANESE DIOXIDE			
Australia	12,300	XX	18,300	18,700	XX	28,100
Belgium	1,180	XX	1,980	1,230	XX	2,130
Brazil	1,270	XX	1,770	848	XX	1,180
Ireland	8,560	XX	12,500	7,300	XX	10,600
South Africa, Republic of	238	XX	347	1,440	XX	1,890
Other 3/	278 r/	XX	653 r/	196	XX	449
Total	23,800	XX	35,500	29,700	XX	44,400
			POTASSIUM PERMANGANATE			
China	1,090	XX	995	420	XX	316
Czech Republic	571	XX	852	453	XX	830
Germany	40	XX	74	100	XX	171
Japan	--	XX	--	109	XX	147
Spain	125	XX	277	352	XX	740
Other 3/	134 r/	XX	465 r/	197	XX	555
Total	1,960	XX	2,660	1,630	XX	2,760

r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes U.S. Bureau of Mines conversion of part of reported data (from apparent MnO2 content to Mn content).

3/ Unspecified group of countries differs from that in the 1993 Annual Report.

Source: Bureau of the Census, adjusted by the U.S. Bureau of Mines.

MANUFACTURED ABRASIVES

By Gordon T. Austin

Manufactured abrasives include fused aluminum oxide, silicon carbide, alumina-zirconia oxide, and metallic shot and grit. Production data for fused aluminum oxide, silicon carbide, and alumina-zirconia oxide were for the United States and Canada. Data for metallic shot and grit were for the United States only.

Fused Aluminum Oxide

Government Programs.—The National Defense Stockpile (NDS), as of December 31, 1994, contained 218,867 tons of crude fused aluminum oxide and 39,824 tons of abrasive-grain fused aluminum oxide. The NDS goals for abrasive-grain fused aluminum oxide and crude fused aluminum oxide are zero; all of the material is targeted for disposal. During 1994, the NDS disposed of 27,216 tons of crude fused aluminum oxide and 6,682 tons of abrasive-grade fused aluminum oxide.

Production.—The U.S. Bureau of Mines (USBM) determines U.S. and Canadian production of crude fused aluminum oxide and the amount of crude sold or used by producers from the "Crude Artificial Abrasives Survey," a voluntary survey of U.S. and Canadian operations. Production and sold or used data were collected from 6 companies operating 11 plants in the United States and Canada and represented 100% of the industry.

At yearend, five firms were producing fused aluminum oxide at eight plants in the United States and Canada. Production of regular-grade fused aluminum oxide in 1994 was 133,000 tons, essentially unchanged from that of 1993.

Production of high-purity fused aluminum oxide increased 37% to 29,000 tons. Total 1994 production of 162,000 tons was 5% more than that of 1993. *(See table 2.)*

Consumption and Uses.—Fused aluminum oxide in the form of graded grain has a number of different end uses. The total value of sales of fused aluminum oxide-graded grain for all uses increased 13% compared to those of 1993, this was a new 10-year high. The value of sales for use in bonded abrasives increased 15%, coated abrasives increased 68%, refractories increased 7%, tumbling media increased 18%, blasting abrasives increased 5%, polishing cake and buffing compounds decreased 18%, antislip abrasives decreased 50%, polishing abrasives increased 17%, and all other uses increased 19%.

Prices.—The USBM did not collect data on the prices of various grades of fused aluminum oxide. It did collect data on the value of fused aluminum oxide production. The average value of regular-grade fused aluminum oxide, as reported by producers, was approximately $361 per ton. In 1994, the average value of high-purity fused aluminum was $557. The average value of all grades of fused aluminum oxide in 1994 was $396 per ton.

Foreign Trade.—The quantity of exports plus reexports of fused aluminum oxide in 1994 increased 16% to about 13,000 tons; the value of exports plus reexports increased about 4% to $29.5 million. The average value per ton of fused aluminum oxide, exported or reexported, decreased 11% to $2,316.

Imports decreased about 8% in 1994 to 145,000 tons, and the value of imports decreased about 9% to $70.3 million.

Silicon Carbide

Government Programs.—The NDS, as of December 31, 1994, contained 28,991 tons of silicon carbide; the goal was zero. During 1994, the Defense National Stockpile Center of the Defense Logistics Agency disposed of 2,517 tons of silicon carbide. Existing legislation authorizes disposal of all of the silicon carbide in the NDS.

Production.—The USBM determines U.S. and Canadian production of crude silicon carbide and the amount of crude sold or used by producers from the "Crude Artificial Abrasives Survey," a voluntary survey of U.S. and Canadian operations. Production and sold or used data were collected from four companies operating five plants in the United States and Canada and represented 100% of the industry. *(See table 1.)*

During 1994, four firms produced silicon carbide at five plants in the United States and Canada. Production of abrasive-grade material increased 13% to about 43,000 tons. Production of metallurgical-grade silicon carbide increased about 13% to 42,000 tons. Total production of silicon carbide increased 13% in 1994 to 85,000 tons. *(See table 2.)*

Consumption and Uses.—Silicon carbide in the form of graded grain has a number of different end uses. The total value of sales of silicon carbide graded grain for all uses increased 12% in 1994. The total value of sales by individual end use was a mixture of increases and decreases. Sales for use in bonded abrasives were up 17%, coated abrasives were up 20%, refectories increased 24%, tumbling media increased 13%, blasting abrasive decreased 5%, wiresawing abrasive increased slightly, polishing cake and buffing compounds were down 56%, antislip abrasives were up 6%, polishing abrasives were down 17%, metallurgical was up 13%, and all other uses were up 37%.

Prices.—The USBM did not collect price data on the various grades of silicon carbide. Data were available on the value of production of the various grades. The average value per ton of abrasive-grade silicon carbide, as reported by producers, was $531; and metallurgical-grade averaged $470; and the average value of all grades was $501.

Foreign Trade.—Exports plus reexports of silicon carbide in 1994 were 16,000 tons, essentially unchanged compared with that of 1993. While the total value of silicon carbide exported plus reexported decreased 9% to $14.4 million, the value per ton decreased 4% to $900.

Imports of silicon carbide in 1994 decreased 4% in quantity to 110,000 tons, the total value was essentially unchanged at $58.3 million. The average value per ton increased 20% to $530.

Alumina-Zirconia Oxide

One firm produced fused alumina-zirconia oxide in two plants, one each in the United States and Canada. Abrasive applications accounted for all the production. Publishing production data would disclose company proprietary data. Export and import data were not available.

Metallic Abrasives

Production.—The USBM determines U.S. production of metallic abrasives and the amount of metallic abrasives sold or used by producers from the "Metallic Abrasives Survey," a voluntary survey of U.S. operations. Production and sold or used data were collected from 13 companies operating 14 plants in the United States and represented 100% of the industry. *(See table 3.)*

The quantity and value of steel shot and grit produced increased about 16% and 22%, respectively. The average value per ton was $406, a 4% increase compared with that of 1993. Michigan, Pennsylvania, Virginia, and Ohio, in decreasing order of quantity, supplied the production of steel shot and grit.

During 1994, four firms, one each Indiana, Michigan, New York, and Ohio reported production of cut wire shot. Production of shot and grit other than steel increased significantly in 1994. *(See tables 4.)*

Consumption.—The quantity of steel shot and grit sold or used increased slightly to 208,000 tons, the total value increased 13% to $89.9 million, and the average value per ton increased 11% to $432.

The quantity of other shot and grit sold or used increased. The value was significantly higher.

Foreign Trade.—U.S. exports and reexports of metallic shot and grit increased 9% to about 31,900 tons. The total value of exports plus reexports increased 11% to $16.3 million, and the average value per ton increased slightly to $511.

U.S. imports of metallic abrasives increased 11% in quantity to 28,900 tons, the value of imports were essentially unchanged at $14.5 million, and the value per ton decreased 7% to $502.

The United States was a net importer of metallic abrasives in 1994 for only the second time in the past 10 years.

Outlook.—The use of manufactured abrasives is very closely tied to the automotive industry, their largest single consumer. The increase or decrease use of manufactured abrasives will be directly related to the number of automobiles, trucks, tractors, and earthmoving equipment built in the United States.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Manfactured Abrasive Chapter Mineral Commodity Summaries, 1995.
Manufactured Abrasives Quarterly MIS.
Abrasive Materials Annual Reports, 1993.

TABLE 1
CRUDE ARTIFICIAL ABRASIVES MANUFACTURERS IN 1994

Company	Location	Product
Dakota Catalyst Products	Williston, ND	Silicon carbide and fused aluminum oxide (high purity).
The Exolon-Esk Co.	Hennepin, IL	Silicon carbide and fused aluminum oxide (regular).
Do.	Thorold, Ontario, Canada	Fused aluminum oxide (regular).
Praxair Surface Technologies, Inc.	Indianapolis, IN	Fused aluminum oxide (regular and high-purity).
Triebacher Schleismittel Corp.	Niagara Falls, NY	Do.
Do.	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular) and silicon carbide.
Saint-Gobain/Norton Industrial Ceramics Corp.	Huntsville, AL	Fused aluminum oxide (high-purity) and aluminum-zirconium oxide.
Do.	Worcester, MA	General abrasive processing.
Do.	Chippawa, Ontario, Canada	Fused aluminum oxide (regular and high-purity) and aluminum-zirconium oxide.
Do.	Shawinigan, Quebec, Canada	Silicon carbide.
Superior Graphite Co.	Hopkinsville, KY	Do.
Washington Mills Electro Minerals (Canada) Corp.	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
Washington Mills Electro Minerals (US) Corp.	Niagara Falls, NY	Fused aluminum oxide (high-purity).
Washington Mills Ltd.	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).

TABLE 2
END USES OF CRUDE SILICON CARBIDE AND ALUMINUM OXIDE (ABRASIVE GRADE) IN THE UNITED STATES AND CANADA, AS REPORTED BY PRODUCERS 1/

Use	1993			1994		
	Quantity (metric tons)	Value (thousands)	Yearend (stocks)	Quantity (metric tons)	Value (thousands)	Yearend (stocks)
SILICON CARBIDE						
Abrasives	38,300	$20,600	1,450	43,100	$22,900	3,340
Metallurgical	36,700	19,300	3,090	41,600	19,500	2,980
Refractories and other	W	W	--	W	W	--
Total	74,900	39,900	4,540	84,700	42,400	6,320
ALUMINUM OXIDE						
Regular: Abrasives and refractories	132,000	48,500	14,400	133,000	47,900	7,300
High purity	21,300	13,200	1,260	29,200	16,300	1,670
Total	154,000	61,700	15,600	162,000	64,200	8,980

W Withheld to avoid disclosing company proprietay data; included with "Metallurgical."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 3
U.S. PRODUCERS OF METALLIC ABRASIVES IN 1994

Company	Location	Product (shot and/or grit)
Abrasive Materials, Inc.	Fortville, IN	Cut wire, steel.
Alcotec Wire Co.	Traverse City, MI	Cut wire.
Barnsteel Abrasives	Brownsville, PA	Annealed iron and steel.
Chesapeake Specialty Products	Baltimore, MD	Steel.
Durasteel Abrasive Co.	Pittsburgh, PA	Do.
Ervin Industries, Inc.	Adrian, MI	Do.
Do.	Butler, PA	Do.
Metaltec Steel Abrasives Co.	Canton, MI	Do.
National Metal Abrasive Co.	Wadsworth, OH	Do.
Peerless Metal Powders & Abrasive	Detroit, MI	Do.
Pellets, Inc.	Tonawanda, NY	Cut wire.
The Platt Brothers, Inc.	Waterbury, CT	Other types.
Premier Shot Co.	Cleveland, OH	Cut wire shot.
The Wheelabrator Co.	Bedford, VA	Steel.

TABLE 4
ANNUAL PRODUCTION, SHIPMENTS, AND PLANT CAPACITIES FOR METALLIC ABRASIVES IN THE UNITED STATES, BY PRODUCT1/ 2/

	Production		Shipments		Capacity 3/
Product	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)
1993:					
Chilled iron shot and grit	W	W	W	W	W
Annealed iron shot and grit	W	W	W	W	W
Steel shot and grit	197,547	$76,832	202,925	$79,216	247,440
Other 4/	15,389	7,746	15,855	8,672	XX
Total	212,936	84,578	218,780	87,888	XX
1994:					
Chilled iron shot and grit	W	W	W	W	W
Annealed iron shot and grit	W	W	W	W	W
Steel shot and grit	229,834	93,405	208,043	89,869	247,440
Other 4/	4,515	5,554	3,641	4,489 5/	XX
Total	234,349	98,959	211,684	94,358	XX

W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable.

1/ Exludes secondary (recycle) producers.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; data may not addd to totals shown.

3/ Total quantity of the various types of metallic abrasives that a plant could have produced during the year, working three 8-hour shifts per day, 7 days per week, allowing for usual interruptions, and assuming adequate fuel, labor, and transportation.

4/ Includes cut wire, aluminum, stainless steel shot, and items indicated by symbol W.

5/ Fourth quarter data for the quantity and value of other shot and grit was withheld from the 1994 total.

MERCURY

By Stephen M. Jasinski

Mercury was produced in the United States only as a byproduct of gold mining. Domestic production data were withheld to protect company proprietary information. The last domestic mercury mine closed in 1990. Domestic consumption continued the downward trend of the past 5 years, falling to 483 metric tons, as many uses of mercury continue to be eliminated each year in favor of less toxic substances. The three largest uses were: the manufacturing of chlorine and caustic soda, which made up 28% of domestic consumption; wiring devices and switches, which accounted for 16%; and measuring and control instruments, which used 11%. Imports of mercury increased in 1994 owing to the suspension of sales in July from the National Defense Stockpile (NDS), which was the major supplier of mercury to the domestic market in 1993. Exports also dropped as less mercury was available. Secondary production increased as more mercury-containing materials were banned from landfill disposal.

The domestic dealer price increased in response to the tighter market situation. The average was $194 per flask. World production decreased in 1994 because of reduced output from Spain and the former USSR. World reserves and reserve base were 130,000 and 240,000 tons, respectively.

Domestic Data Coverage

For consumption and stock data, 37 companies were canvassed and 76% responded. The respondents accounted for an estimated 88% of consumption.

Legislation and Government Programs

The Defense Logistics Agency (DLA) sold 86 tons of mercury from the National Defense Stockpile in 1994. Sales were suspended in July after the U.S. Environmental Protection Agency (EPA) had questions about potential environmental problems associated with the release of mercury. Also, there were concerns about NDS mercury being exported for uses eliminated or reduced in the United States. Sales were not to resume until the EPA and DLA determine how to dispose of the NDS mercury in an environmentally responsible manner. The DLA was authorized to sell 690 tons of mercury in FY 1995 and proposes to sell 690 tons in FY 1996. The NDS inventory on December 31 was 4,408 tons. No mercury was sold from the 167 tons held by the Department of Energy at Oak Ridge, TN.

Several States, primarily in the Northeast, issued warnings in 1994 against eating freshwater fish because of elevated levels of mercury. The U.S. Food and Drug Administration has set a level of 1 part per million mercury in fish as the safe maximum limit for human consumption. Most States limits, however, are 0.5 part per million. In New Jersey, fish in several lakes in the Pine Barrens have shown limits above 0.5 part per million and 70% had levels above 1 part per million. This prompted warnings against eating the fish in this area of the State. In Maine, which has a limit of 0.43 part per million, pregnant women and children under 8 years of age were advised not to eat any fish from lakes or ponds; other adults were advised to restrict their intake. Michigan was the only other State to issue a statewide warning. Other States in New England issued regional advisories against fish consumption.

In Minnesota, a new State law prohibits the disposal of thermostats and other mercury-containing devices unless the mercury has been removed. It also requires that manufacturers of thermostats provide incentives to induce purchasers to properly manage used thermostats. In response to this regulation, Honeywell, Inc., a major manufacturer of thermostats, started a recycling program involving wholesalers and dealers of heating and cooling equipment in Minnesota. The wholesalers collect the thermostats and return them to Honeywell where the mercury bulbs are removed and shipped to a mercury reprocessor for redistilling. The mercury is then shipped back to Honeywell.[1]

An EPA survey determined that 341 tons of mercury had been emitted to the atmosphere in 1993 from domestic sources. The largest volumes of emissions came from the combustion of fossil fuel, primarily coal at powerplants and incinerators.

Production

The only prime virgin mercury produced was a byproduct of gold mining in California, Nevada, and Utah. Reported production was withheld to avoid disclosing company proprietary data. Secondary production continued to increase in response to greater restrictions being placed on the disposal of mercury-containing products. Secondary production was 466 tons in 1994. Mercury was recovered from a variety of waste materials, such as batteries, dental amalgams, switches (including thermostats), manometers, chlor-alkali wastewater sludges, chemical solutions, and fluorescent light tubes. Three companies were the major refiners: Bethlehem Apparatus Co., Hellertown, PA; D. F. Goldsmith Co., Evanston, IL; and Mercury Refining Co., Albany, NY. Four other companies also produced secondary mercury. Nine companies, with a total of 23 plants, recycled only fluorescent lamps; however, only 12 of the plants recovered mercury, while the others shipped the sorted waste materials to domestic refiners for further processing.

Consumption

Domestic consumption dropped 15% to 483 tons. The use of mercury in the production of chlorine and caustic soda fell 45 tons in 1994 because of the conversion of several plants to membrane cell technology and increased onsite recycling of wastewater sludges, which eliminates the need to purchase mercury. The use of mercury in lighting, which has averaged 31 tons per year since 1990, was 27 tons.

Mercury use in batteries fell to 6 tons. Currently, the only consumer battery type to have added mercury is the alkaline button cell. Mercuric oxide batteries are still produced for military and medical equipment, but research is continuing in development of acceptable substitute batteries for those uses.

Prices

Mercury usually is sold by the 34.5 kilogram flask. The Platt's Metals Week domestic dealer average price for the year was $194 per flask.

World Review

World production decreased more than 500 tons in 1994, because of reduced output in Kyrgyzstan, Spain, Tajikistan, and Ukraine. Minas de Almaden, of Spain, produced 300 tons of mercury in 1994, all in the last quarter of the year, compared with 643 tons in 1993. Mercury production was restarted reportedly to replenish stocks.

Outlook

Mercury will continue to be used only where it is necessary, such as in switches, thermostats, and fluorescent lighting. Domestic demand should stabilize in the next few years as nonessential uses are either banned or voluntarily eliminated. Secondary production will become an even more important component of domestic supply, especially if the ban on DLA mercury continues.

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[1] Sass, B. M., M. Salem, and L. Smith Mercury Usage and Alternatives in the Electrical and Electronics Industries (U.S. EPA Contract 68-CO-0003, Battelle). EPA Rep. 600/R-94/047, Jan. 1994, 48 pp.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Mercury. Ch. in Mineral Commodity Summaries, annual.

Other Sources

American Metal Market (daily newspaper).
Metal Bulletin (London).
Platt's Metals Week.

TABLE 1
SALIENT MERCURY STATISTICS 1/

(Metric tons, unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Producing mines	9	8	9	9	7
Mine production:					
Principal product 2/	448	--	--	--	--
Byproduct	114	58	64	W	W
Secondary production:					
Industrial	108	165	176	350	466
Government 3/	193	215	103	--	--
Shipments from the National Defense Stockpile 4/	52	103	267	543	86
Imports for consumption	15	56	92	40	129
Exports	311	786	977	389	316
Industry stocks, yearend 5/	197	313	436	384	368
Industrial consumption	720	554	621	558	483
Price: New York, average per flask	$249.22	$122.42	$201.39	$187.00	$194.45
Employment, mine and mill, average 6/	21	3	--	--	--
World:					
Mine production	4,100	2,540	1,890 r/	2,290 r/	1,760 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Comprises only the mercury produced at the McDermitt Mine, as reported in Placer Dome Inc. annual and 10 - K reports. The mine was closed in November 1990.

3/ Secondary mercury shipped from U.S. Department of Energy stocks.

4/ Primary mercury.

5/ Stocks at consumers and dealers only. Mine stocks withheld to avoid disclosing company proprietary data.

6/ McDermitt mine only.

TABLE 2
BYPRODUCT MERCURY-PRODUCING MINES IN THE UNITED STATES IN 1994

Mine	County and State	Operator
Alligator Ridge	White Pine, NV	Placer Dome U. S.
Carlin Mines Complex	Eureka, NV	Newmont Gold Co.
Enfield Bell	Elko, NV	Independence Mining Co Inc.
Getchell	Humboldt, NV	FMC Gold Co.
McLaughlin	Napa, CA	Homestake Mining Co.
Mercur	Tooele, UT	Barrick Mercur Gold Mines Inc.
Paradise Peak	Gabbs, NV	FMC Gold Co.

TABLE 3
U. S. INDUSTRIAL CONSUMPTION OF REFINED MERCURY METAL, BY USE 1/

(Metric tons)

SIC Code	Use	1993	1994
28	Chemical and allied products:		
2812	Chlorine and caustic soda manufacture	180	135
2819	Laboratory uses	26	24
--	Other chemical and allied products 2/	18	25
36	Electrical and electronic uses:		
3641	Electric lighting	38	27
3643	Wiring devices and switches	83	79
3692	Batteries	10	6
38	Instruments and related products:		
382	Measuring and control instruments	65	53
3843	Dental equipment and supplies	35	24
--	Other uses 3/	103	110
	Total	558	483

1/ The input of refined liquid mercury to domestic manufacturing establishments.

2/ Includes pharmaceutical uses and miscellaneous catalysts.

3/ Includes other electrical and electronic uses, other instruments and related products, and unclassified uses.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF MERCURY AND MERCURY-BEARING WASTE AND SCRAP, AND EXPORTS, BY COUNTRY 1/

Country	1993 Metric tons	1993 Value (thousands)	1994 Metric tons	1994 Value (thousands)
		Imports		
Canada	34	$49	5	$8
Russia	--	--	117	290
Other	5 2/	94 2/	6	196
Total	40	143	129	494
		Exports		
Hong Kong	52	136	87	242
India	96	186	149	249
Netherlands	108	308	2	20
Venezuela	55 3/	148 3/	--	--
Other	78 2/	452 2/	78	373
Total	389	1,230	316	885

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Unspecified group of countries differs from that published in the 1993 Annual Mineral Industry Survey, Annual Review.

3/ All or part of these data have been referred to the Bureau of the Census for verification.

Source: Bureau of the Census.

TABLE 5
MERCURY: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Algeria	637	431	476	475 e/	475
China e/	1,000	760	580 r/	520 r/	500
Czechoslovakia 3/ 4/	126	75	60	XX	XX
Finland	141	74	85	98 r/ e/	100
Kyrgyzstan e/	XX	XX	300	250	200
Mexico	735	340	21	12 r/	10
Morocco 5/	--	20	20 e/	20 e/	20
Russia e/	XX	XX	70	60	--
Slovakia 4/	XX	XX	XX	50 e/	50
Slovenia e/ 6/	XX	XX	7	--	--
Spain	--	--	--	643	300
Tajikistan e/	XX	XX	100	80	55
Turkey	60	25	5	--	--
U.S.S.R. e/ 7/	800	750	XX	XX	XX
Ukraine e/	XX	XX	100	80	50
United States 8/	562	58	64	W	W
Yugoslavia 6/ 9/	37	9	XX	XX	XX
Total	4,100	2,540	1,890 r/	2,290 r/	1,760

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through Apr. 24, 1995.

3/ Dissolved Dec. 31, 1992.

4/ All production in Czechoslovakia from 1990-92 came from Slovakia.

5/ Mercury was produced only as a byproduct of silver mining.

6/ All production in Yugoslavia from 1990-91 came from Slovenia.

7/ Dissolved in Dec. 1991.

8/ For 1990, data are the combined output from the McDermitt Mine, as reported in the Randol Mining Directory, and from mercury produced as a byproduct of gold mining operations. Beginning in 1991, mercury was produced only as a byproduct of gold mining.

9/ Dissolved in Apr. 1992.

MICA

By James B. Hedrick

Mica is a group of phyllosilicate minerals that have a layered or platy texture. The commercially important micas are muscovite and phlogopite. Composed of tetrahedral-octahedral-tetrahedral layers, the mica group is characterized by partial substitution of aluminum for silicon in the silicate tetrahedron. This substitution in the laminar structure provides charges to bind interlayer univalent and divalent cations, typically potassium, magnesium, calcium, and sodium. Layering in the univalent (potassium, sodium) or "true" micas imparts perfect basal cleavage, allowing crystals to be split into very thin sheets that are tough and flexible. Layering in the divalent or "brittle" micas also imparts perfect basal cleavage; however the greater bond strengths make them more brittle and less flexible.

The value of mica is in its unique physical properties. The crystalline structure of mica forms minerals that can be split or delaminated into thin sheets that are platy, flexible, elastic, transparent to opaque, resilient, reflective, dielectric, chemically inert, insulating, lightweight, hydrophilic, nonconductive to heat and electricity, and stable to temperature extremes, electricity, light, and moisture. Muscovite is the principal mica used, based on its greater abundance and superior electrical properties. Phlogopite remains stable at higher temperatures and is used in applications where a combination of high heat stability and electrical properties is required. Muscovite and phlogopite are used in both sheet and ground forms.

In 1994, about 109,000 metric tons of scrap and flake mica was produced in the United States, an increase of 25% from 1993. (*See table 1.*) Ground mica sales were 95,000 tons valued at $28.7 million, an increase in tonnage of 2%. Essentially all of the sheet mica used in the United States was imported. Consumption of muscovite block mica increased more than 20% to 6.5 tons, valued at $432,000. Consumption of mica splittings increased from 826 tons in 1993 to 857 tons in 1994. The value of sheet mica exports increased 33% to $12.7 million. The value of imports for consumption of sheet mica increased 23% to $14.6 million. *(See table 1.)*

Legislation and Government Programs

The calendar year 1994 included the U.S. Government fiscal years for 1994 and 1995. Public Law 103-160, the National Defense Authorization Act for Fiscal Year 1994, was enacted on November 30, 1993, and covered the year 1994 through September 30. It continued specific previous authorizations for disposal of stocks in the National Defense Stockpile (NDS) classified as excess to goal. The National Defense Authorization Act for Fiscal Year 1995, Public Law 103-337, was enacted on October 5, 1994, and covered the last 3 months of 1994. Stocks of mica classified as excess to goal at the end of fiscal year 1994 included 2,018,637 kilograms of muscovite block (stained and better), 465,289 kilograms of muscovite film (1st and 2nd qualities), 6,327,888 kilograms of muscovite splittings, and 583,341 kilograms of phlogopite splittings. Phlogopite block in the stockpile is 84,265 kilograms below the goal of 143,570 kilograms. Yearend NDS data are shown in table 2.

Production

Domestic mine production data for mica are developed by the U.S. Bureau of Mines (USBM) from three separate, voluntary surveys and one mandatory survey. Of the 17 operations to which the *Crude Scrap and Flake Mica* production form was sent, 11 operations, or 65% responded (one operation closed and three were idled), representing 85% of the production shown in table 1. Of the 17 operations to which the *Ground Mica* form was sent, 14 operations, or 82% responded (one operation closed) representing 89% of the domestic ground mica production noted in table 1 (excluding low-grade sericite production). Of the five surveyed operations to which the *Mica Block and Film* consumption form was sent, four operations, or 80% responded, representing 94% of the muscovite block consumption shown in table 1. Of the nine surveyed operations to which the *Mica Splittings* consumption form was sent, nine operations, or 100% responded, representing 100% of the splittings consumption presented in table 1. Consumption for the nonrespondents was estimated using prior-year production data. Individual company production and consumption data are withheld to avoid disclosing company proprietary data.

Scrap and Flake Mica.—Nine domestic companies with 12 mines in 5 States produced scrap and flake mica in 1994. The United States was the world's largest producer with 109,000 tons. North Carolina remained the major producing State, with 62% of domestic production. The remainder was produced in Georgia, New Mexico, South Carolina, and South Dakota. Most mica was recovered from mica schist, high-quality sericite schist, weathered pegmatites, and as a byproduct of feldspar, kaolin, and lithium. *(See table 3.)*

The scrap and flake mica producers, in alphabetical order, were Aspect Mineral, Micaville, NC; The Feldspar Corp., Spruce Pine, NC; FMC Corp. Lithium Division, Bessemer City, NC; FMP Division of The Mearl Corp., Hartwell, GA; KMG Minerals Div. of Franklin Industries Inc., Kings Mountain, NC and Velarde, NM; K-T Feldspar Corp., Spruce Pine, NC; The Mineral Mining Co., Kershaw, SC; Pacer Corp., Custer, SD; and Unimin Corp., Spruce Pine, NC.

Ground Mica.—Nine companies operated 12 grinding plants in 5 States. Eight plants produced dry-ground mica and four plants produced wet-ground mica. The four largest ground mica companies, including one company with four plants, accounted for 79% of the total of 95.4 tons. *(See table 4.)*

Dry ground mica producers, in alphabetical order, were: Asheville Mica Co., Asheville, NC; KMG Minerals Division of Franklin Industries Inc., Kings Mountain, NC and Velarde, NM; Mineral Mining Co. Inc., Kershaw, SC; Pacer Corp, Custer, SD; Spartan Minerals Corp., a subsidiary of FMC Corp. Lithium Division, Pacolet, SC; and USG Corp., Spruce Pine, NC. Wet ground mica producers, in alphabetical order, were: Aspect Mineral, Bakersville, NC; the FMP Division of The Mearl Corp., Hartwell, GA and Franklin, NC; and KMG Minerals Division of Franklin Industries Inc., Kings Mountain, NC.

United States.—Franklin Industrial Minerals Co. of Nashville, TN, acquired the operations of KMG Minerals Inc., Kings Mountain, NC, making it the largest producer of ground mica in the United States.[3] Franklin, which already had facilities in Velarde, NM, now operates an additional mine and three grinding plants at Kings Mountain, NC. The new company, KMG Minerals, Division of Franklin Industries Inc., had a combined mica production capacity of over 50,000 tons per year. KMG also produced potassium feldspar, kaolin, and silica sand.

Consumption

Statistics on domestic mica consumption are developed by surveying various processors and manufacturers, evaluating import-export data, and analyzing Government stockpile shipments.

Sheet Mica.—Sheet mica is used principally in the electronic and electrical industries. Its usefulness in these applications stems from its unique electrical and thermal insulating properties and its mechanical properties, which allow it to be cut, punched, stamped, and machined to close tolerances.

The largest use of block mica is as an electrical insulator in electronic equipment. High-quality mica is also used to line the gauge glasses of high-pressure steam boilers because of its transparency, flexibility, and resistance to heat and chemical attack. Other uses include diaphragms for oxygen-breathing equipment, marker dials for navigation compasses, optical filters, retardation plates in helium-neon lasers, pyrometers, thermal regulators, and stove and kerosene heater windows. Specialized applications for sheet mica are found in ground and air-launched missile systems, optical instrumentation, laser devices, medical electronics for radiation treatment, radar systems, and aerospace components.

Muscovite film mica is used as a dielectric in capacitors. Only high-quality mica is used in this application. The highest grade film is used in capacitors that are manufactured as calibration standards. The next grade down is used in transmitting capacitors. Receiving capacitors use a slightly lower grade of high-quality muscovite.

Consumption of muscovite block (ruby and nonruby) totaled 6,500 kilograms, a 20% increase from that of 1993. Stained and lower-than-stained quality remained in greatest demand, accounting for 92% of ruby mica block and 66% of nonruby mica block consumption. The year 1994 was a turnaround from the long-term decline in the use of block mica. Five companies continued to consume muscovite block and film in five plants in four States: two in North Carolina, and one each in New Jersey, Ohio, and Virginia.

Mica splittings represents the largest part of the sheet mica industry in the United States. Muscovite and phlogopite splittings are used to make built-up mica. Consumption of muscovite and phlogopite splittings increased 3.8% in 1994 to 857 tons. *(See table 6.)* Muscovite splittings from India accounted for nearly all of domestic consumption. The remainder of consumption was phlogopite splittings imported from Madagascar. The splittings were fabricated into various built-up mica products by nine companies operating nine plants in six States

Built-up Mica.—Produced by mechanical or hand setting of overlapping splittings and alternate layers of binders and splittings, built-up mica is primarily used as an electrical insulation material. Major products are molding plate, segment plate, flexible plate, tape, heater plate, mica paper, and bonding materials. *(See table 7.)*

Segment plate acts as insulation between the copper commutator segments of direct-current universal motors and generators. Phlogopite built-up mica is preferred because it will wear at the same rate as the copper segments. Muscovite has a greater resistance to wear, causing uneven ridges that may interfere with the operation of a motor or generator. Consumption of segment plate was 246 tons in 1994.

Molding plate is sheet from which V-rings are cut and stamped for use in insulating the copper segments from the steel shaft ends at the ends of a commutator. Molding plate is also fabricated into tubes and rings for insulation in transformers, armatures, and motor starters. Consumption of molding plate reached 198 tons in 1994.

Flexible plate is used in electric motor and generator armatures, field coil insulation, and magnet and commutator core insulation. Mica consumption in flexible plate was 109 tons.

Heater plate is used where high-temperature insulation is required. Consumption in heater plate totaled 21 tons. Tape, powdered mica paper, and silicone and other bonding materials consumed 145 tons.

Some types of built-up mica have the bonded splittings reinforced with special paper, silk, linen, muslin, glass, cloth, or plastic. These products are very flexible and are produced in wide, continuous sheets that are either shipped rolled or cut into ribbons, tapes, or trimmed to specified dimensions.

Total consumption of built-up mica that was consumed or shipped was 719 tons, an increase of 10% from the 1993 level. Segment plate and molding plate were the major end products and accounted for 34.2% and 27.5% of the total, respectively.

Reconstituted Mica (Mica Paper).—Primary uses for mica paper are the same as those for built-up mica. Three companies consumed scrap mica to produce mica paper. The principal source of the scrap was India. Manufacturing companies in 1994 were Corona Films Inc., West Towsend, MA; General Electric Co., Coshocton, OH; and U.S. Samica Corp., Rutland, VT.

Ground Mica.—The largest domestic use of dry ground mica was in joint compound for filling and finishing seams and blemishes in wall board (drywall). The mica acts as a filler and extender, provides a smooth consistency, improves the workability of the compound, and imparts resistance to cracking. Joint compound accounted for 53.5% of dry ground mica consumption.

In the paint industry, ground mica is used as a pigment extender that also facilitates suspension, reduces chalking, prevents shrinking and shearing of the paint film, increases resistance of the paint film to water penetration and weathering, and brightens the tone of colored pigments. Mica also promotes paint adhesion in both aqueous and oleoresinous formulations. Consumption of dry ground mica in paint, its second largest use, accounted for 27.4% of the 1994 total.

Ground mica is used in the well-drilling industry as an additive to drilling muds. The coarsely ground mica flakes help prevent loss of circulation by sealing porous sections of the drill hole.

The rubber industry uses ground mica as an inert filler and as a mold release compound in the manufacture of molded rubber products, such as tires and roofing. The platy texture acts as an antiblocking, antisticking agent.

The plastics industry uses dry ground mica as an extender and filler, especially in parts for automobiles for lightweight insulation to suppress sound and vibration. Mica is used in plastic automobile fascia and fenders as a reinforcing material, providing improved mechanical properties, increased strength, stiffness, and dimensional stability. Mica-reinforced plastics also have high-heat dimensional stability, reduced warpage, and the best surface properties of any filled plastic composite. Consumption of dry ground mica in plastic applications accounted for 2% of the market in 1994.

Ground mica is used in the production of rolled roofing and asphalt shingles, where it serves as a surface coating to prevent sticking of adjacent surfaces. The coating is not absorbed by freshly made roofing because mica's platy structure is unaffected by the acid in asphalt or by weathering conditions. As a rubber additive, mica reduces gas permeation and improves resiliency.

Other uses include decorative coatings on wallpaper, concrete, stucco, and tile surfaces. It is also used as an ingredient in some special greases, as a flux coating on welding rods, and in foundry applications as coatings for core and mold release compounds, mold washes, and facing agents.

Stocks

Government stocks of mica in the NDS are comprised of stockpile grade muscovite block, stained and better; muscovite film, first and second quality; muscovite splittings; phlogopite block; and phlogopite splittings. NDS stocks of muscovite block, muscovite film, and muscovite and phlogopite splittings were available for sale from the Defense National Stockpile Center, Fort Belvoir, VA. Yearend 1994 stocks of various types of mica in the NDS are shown in table 2.

Reported yearend industry stocks of muscovite mica block (ruby and nonruby) decreased from 28.8 tons in 1993 to 24.6 tons in 1994. Industry stocks of muscovite and phlogopite mica splittings increased from 427 tons at yearend 1993 to 480 tons at yearend 1994. *(See table 6.)*

Prices

Sheet mica prices vary with grade and can range from less than $1 per kilogram for low-quality mica to more than $2,000 per kilogram for the highest quality. The average values of muscovite sheet mica consumed in the United States in 1994 compared with 1993 were as follows: block (ruby and nonruby) decreased 31% to $66 per kilogram and splittings increased 3% to $1.59 per kilogram.

The average value of phlogopite block decreased 11% to $23 per kilogram, while the average value of phlogopite splittings increased 2% to $4.45 per kilogram. The changes in average value are more a reflection of the quality of sheet mica consumed during the year than actual changes in prices.

The average value of crude flake mica, including high-quality sericite, was $66 per ton. The average value for North Carolina flake mica, primarily a flotation product, decreased from $53 per ton in 1993 to $47 per ton in 1994.

In 1994, the value of dry ground mica averaged $151 per ton while wet ground mica averaged $1,007 per ton.

World Review

The year 1994 was an excellent year for U.S. mica producers and processors. Foreign trade improved with the value of U.S. exports of mica products reaching $15.9 million, up 30% from the previous year. The combined value of mica imports also increased, gaining 28% to $27.1 million. *(See table 13.)*

Domestic ground mica exports increased to 5,840 tons, up 1,200 tons from the 1993 level. Exports of crude and rifted mica also increased, up 52% to 684 tons. *(See table 8.)* Exports of worked mica sheet in 1994 gained 21% to 747 tons. *(See table 9.)* The value of U.S. exports of worked mica sheet was $12.3 million.

The United States continued to rely on imports, primarily from India, for essentially all of its supply of sheet mica and paper-quality scrap mica. Imports for consumption of unmanufactured block, film, and splittings were about 1,040 tons, 63% less than in 1993. *(See table 10.)*

About 16,300 tons of ground mica was imported in 1994, mostly from Canada. *(See table 11.)* Worked mica imports were 8% higher than the previous year, at 1,450 tons. *(See table 12.)*

World production of mica increased 9% to 241,000 tons, primarily the result of increased production in the United States. Major world producers of ground mica continued to be the United States and Russia, while India continued to be the principal producer of sheet mica. *(See table 14.)*

India.—Mica mines are operated in the States of Bihar, Andhra Pradesh, and Rajasthan. In Rajasthan, the principal mines are at Banjari, Barla, Bhojpura, Chapi, Galwa, Ganeshpur, Ghegas, Laxmi, and Sidiras. Most mica production in the region is reportedly ruby muscovite, grading stained and lower.[1]

United Kingdom.—Microfine Minerals Ltd. of the United Kingdom purchased the mica holdings of L. H. Torkildsen AS of Bergen, Norway, and its Silverit tradename. Microfine purchased the Norwegian company to obtain its market share and planned to produce the Silverit line of wet ground mica products at its existing facilities at Derby. Only three other European countries, Finland, France, and Germany, are presently producing wet ground mica for pearlescent pigments, plastic fillers, and cosmetics.[2]

Outlook

The outlook for mica is diverse with demand driven by several factors. The major markets for mica, joint compounds and paints, are mature and relatively stable with overall growth tied to new housing starts and interest rates. To a lesser extent, widespread natural disasters affect the market, creating immediate demand for residential materials. Demand is also responsive to automobile production since interior and exterior parts typically contain dry ground mica, while exterior surfaces are sprayed with wet ground mica pearlescent pigments and mica-containing coatings.

Demand for crude mica is expected to continue to improve in the short-term to meet increasing demand for both dry and wet ground micas. Markets for dry ground mica are forecast to be very good through the year 2000, unless interest rates escalate above yearend 1994 levels. Wet ground mica demand is also expected to show growth as the automotive industry utilizes increasing amounts of pearlescent paint pigments.

Demand for block mica rebounded in 1994 after several years of decline. Domestic markets for block mica are expected to expand slowly through the end of the century, although a shortage of good quality material will continue.

Consumption of mica splittings, the major type of sheet mica consumed in the United States, decreased sharply throughout the 1960's and 1970's and leveled off in the 1980's to between 900 and 1,000 tons per year. With no new uses, demand for splittings is expected to remain stable, with splittings continuing to be used primarily in electrical parts and bonding formulations. Consumption of mica splittings in the second half of the 1990's is forecast to remain between 800 and 1,000 tons per year.

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[1] Industrial Minerals (London). Industrial Minerals of Rajasthan. No. 316, Jan. 1994, pp. 44-51.

[2] ———. Norway-Microfine Buys Silverit Mica. No. 324, Sept. 1994, p. 20.

[3] ———. Franklin Acquires KMG Minerals. No. 326, Nov. 1994, p. 14.

TABLE 1
SALIENT MICA STATISTICS 1/

		1990	1991	1992	1993	1994
United States:						
Production (sold or used by producers):						
Scrap and flake mica	thousand metric tons	109	103	85	88	109
Value	thousands	$5,810	$5,540	$4,640	$4,450	$7,270
Ground mica	thousand metric tons	97	75	84	92	95
Value	thousands	$21,600	$17,300	$21,800	$27,000	$28,700
Prices, dollars per metric ton:						
Scrap and flake mica		$54	$54	$51	$51	$56
Ground:						
Wet		$663	$640	$745	$838	$1,010
Dry		$151	$150	$168	$152	$151
Sheets, dollars per kilogram:						
Block		$92	$85	$80	$95	$56
Splittings		$1.55	$1.54	$1.53	$1.55	$1.53
Consumption:						
Block, muscovite	metric tons	6	6	6	5	6
Value	thousands	$554	$502	$447	$509	$432
Splittings	metric tons	842	854	836	826	857
Value	thousands	$1,410	$1,430	$1,390	$1,390	$1,470
Exports	metric tons	5,660	4,900	5,040	5,860	7,520
Imports	do.	15,900 r/	15,700	18,800	22,200	25,200
World: Production	do.	217,000 r/	211,000 r/	206,000 r/	196,000 r/	214,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

TABLE 2
STOCKPILE STATUS AND GOVERNMENT INVENTORIES FOR MICA, DECEMBER 31, 1994 1/

(Metric tons)

Material	Inventory		Available for disposal	1994 sales
	Stockpile grade	Non stockpile grade		
Block:				
Muscovite, stained and better	2,070	88	1,990	31
Phlogopite	8	52	--	--
Film: Muscovite, 1st and 2nd qualities	465	(2/)	465	41
Splittings:				
Muscovite	6,330	--	6,310	41
Phlogopite	583	--	568	22

1/ Data rounded by the U.S. Bureau of Mines to three significant digits.

2/ Less than 1/2 unit.

TABLE 3
SCRAP AND FLAKE MICA 1/ 2/ SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE

(Thousand metric tons and thousand dollars)

	1993		1994	
State	Quantity	Value	Quantity	Value
North Carolina	51	2,700	68	3,270
Other States 3/	37	1,760	42	4,000
Total	88	4,450	109	7,270

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes finely divided mica recovered from mica schist and high-quality sericite schist, and mica that is a byproduct of feldspar, kaolin and lithium beneficiation.

3/ Includes Georgia, New Mexico, South Carolina, and South Dakota.

TABLE 4
GROUND MICA SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY END USE AND METHOD OF GRINDING 1/ 2/

(Thousand metric tons and thousand dollars)

	1993			1994		
	Quantity	Value	Unit value	Quantity	Value	Unit value
End use:						
Joint cement	49	7,550	$154 r/	42	8,110	$193
Paint	16	3,100 r/	194 r/	26	4,790	184
Plastics	4	1,650	412 r/	2	509	255
Well-drilling mud	4	560	140 r/	3	556	185
Other 3/	19	14,100 r/	742 r/	22	14,700	639
Total	92	27,000	293	95	28,700	302
Method of grinding:						
Dry	W	W	152	W	W	151
Wet	W	W	838	W	W	985

r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits ; may not add to totals shown.

2/ Domestic and some imported scrap. Low-quality sericite is not included.

3/ Includes mica used for molded electrical insulation, roofing, rubber, textile and decorative coatings, welding rods, and miscellaneous.

TABLE 5
FABRICATION OF MUSCOVITE BLOCK MICA IN THE UNITED STATES, BY QUALITY

(Metric tons)

Quality	1993	1994
Good stained or better	674	807
Stained or lower 1/	4,690	5,690
Total	5,360	6,500

1/ Includes punch mica.

TABLE 6
CONSUMPTION AND STOCKS OF MICA SPLITTINGS IN THE UNITED STATES

Year	Consumption		Stocks on Dec. 31 (metric tons)
	Quantity (metric tons)	Value (thousands)	
1993	826	$1,390	427
1994	857	1,470	480

TABLE 7
BUILT-UP MICA 1/ 2/ SOLD OR USED IN THE UNITED STATES, BY PRODUCT

	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Flexible (cold)	104	$551	109	$549
Heater plate	W	W	W	W
Molding plate	210	1,720	198	1,520
Segment plate	213	1,380	246	1,620
Tape	W	W	W	W
Other	124	1,070	126	1,200
Total	651	4,720	679	4,890

W Withheld to avoid disclosing company proprietary data; included in "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Consists of alternating layers of binder and irregularly arranged and partly overlapped splittings.

TABLE 8
U.S. EXPORTS OF CRUDE AND RIFTED MICA, MICA POWDER, AND WASTE IN 1994, BY COUNTRY 1/

Country	Crude and rifted				Powder		Waste	
	Less than $0.55 per kilogram		More than $0.55 per kilogram					
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	--	--	--	--	17	$8	--	--
Australia	--	--	--	--	485	183	--	--
Bahamas, The	--	--	1	$18	--	--	--	--
Barbados	--	--	--	--	11	11	--	--
Belgium	--	--	--	--	23	132	--	--
Brazil	--	--	94	66	4	6	--	--
Canada	18	$8	--	--	2,570	1,050	241	$52
Chile	--	--	--	--	2	3	--	--
Colombia	32	11	--	--	213	136	--	--
El Salvador	12	4	--	--	--	--	--	--
France	31	11	24	18	274	283	--	--
French Polynesia	--	--	--	--	3	3	--	--
Germany	69	16	--	--	51	46	--	--
Guatemala	--	--	--	--	6	6	--	--
Hong Kong	--	--	--	--	1	5	4	6
India	35	5	48	72	--	--	--	--
Ireland	--	--	--	--	16	3	--	--
Italy	--	--	--	--	121	24	--	--
Jamaica	--	--	18	14	--	--	--	--
Japan	--	--	3	20	509	279	--	--
Korea, Republic of	63	23	9	10	310	227	--	--
Malaysia	--	--	10	7	--	--	--	--
Mexico	60	21	--	--	418	219	--	--
Netherlands	11	4	42	174	3	12	--	--
New Zealand	18	5	--	--	267	68	--	--
Nicaragua	--	--	6	5	--	--	--	--
Pakistan	--	--	--	--	15	14	--	--
Peru	--	--	--	--	14	7	--	--
Philippines	--	--	--	--	31	27	--	--
Singapore	--	--	--	--	117	44	--	--
Spain	--	--	--	--	2	7	--	--
Sweden	--	--	--	--	17	11	--	--
Switzerland	--	--	--	--	7	6	--	--
Taiwan	--	--	--	--	100	50	--	--
Thailand	--	--	--	--	1	15	--	--
United Kingdom	21	7	2	6	111	66	--	--
Uruguay	25	9	--	--	9	9	--	--
Venezuela	32	11	--	--	115	81	--	--
Total	428	136	256	410	5,840	3,040	244	58

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 9
U.S. EXPORTS OF WORKED MICA IN 1994, BY COUNTRY 1/

Country	Plates, sheets		Other	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Argentina	1	$20	--	--
Aruba	1	6	--	--
Australia	19	142	20	$80
Bahamas, The	2	9	28	53
Barbados	7	15	--	--
Belgium	27	694	--	--
Belize	1	5	--	--
Bermuda	1	18	--	--
Brazil	22	557	2	78
Canada	138	3,480	57	1,110
Cayman Islands	1	6	2	12
Chile	3	26	(2/)	11
Colombia	13	171	(2/)	5
Costa Rica	2	13	--	--
France	36	339	2	52
Germany	6	110	--	--
Greece	--	--	(2/)	3
Guatemala	(2/)	3	4	15
Haiti	7	10	--	--
Hong Kong	--	--	1	31
Hungary	3	72	2	3
India	2	78	--	--
Italy	23	539	--	--
Japan	12	335	55	97
Korea,Republic of	15	161	2	52
Kuwait	--	--	(2/)	12
Mexico	39	879	129	2,250
Netherlands	--	--	(2/)	9
Netherlands Antilles	--	--	5	16
Nicaragua	--	--	2	4
Nigeria	(2/)	5	--	--
Pakistan	--	--	(2/)	6
Panama	13	31	3	74
Peru	2	90	--	--
Poland	--	--	1	5
Portugal	(2/)	5	--	--
Singapore	1	21	1	18
South Africa, Republic of	1	22	1	4
St. Lucia	--	--	(2/)	3
Suriname	1	10	--	--
Switzerland	2	72	3	90
Taiwan	14	35	2	49
Thailand	1	11	(2/)	3
Turks and Caicos Islands	--	--	1	7
United Kingdom	8	104	1	11
Venezuela	--	--	1	14
Total	422	8,090	325	4,180

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown
2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF CRUDE AND RIFTED MICA IN 1994, BY COUNTRY

Country	Split block		Splittings		Other			
					Less than $0.55 per kilogram		More than $0.55 per kilogram	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Canada	--	--	--	--	19	$4	2	$15
China	--	--	9	$21	--	--	71	184
Finland	--	--	--	--	853	270	--	--
France	1	$11	--	--	--	--	(1/)	4
Germany	--	--	--	--	202	41	--	--
Hong Kong	--	--	--	--	--	--	1	8
India	77	190	935	1,050	4,100	876	19	33
Japan	(1/)	9	--	--	--	--	2	23
Madagascar	1	5	--	--	--	--	--	--
Sri Lanka (Ceylon)	--	--	18	20	--	--	--	--
United Kingdom	(1/)	2	--	--	--	--	--	--
Venezuela	--	--	--	--	--	--	17	159
Total 2/	78	217	962	1,100	5,170	1,190	112	425

1/ Less than 1/2 unit.

2/ Data rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF MICA POWDER AND WASTE IN 1994, BY COUNTRY 1/

Country	Powder		Waste	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Austria	20	$5	--	--
Canada	15,800	7,190	(2/)	$4
Finland	17	4	--	--
France	1	11	36	37
Germany	37	150	--	--
India	--	--	1,070	540
Japan	263	3,030	--	--
Korea, Republic of	10	87	--	--
Madagascar	--	--	36	37
Mexico	--	--	13	29
Netherlands	30	17	--	--
Norway	210	140	--	--
Total	16,300	10,600	1,160	647

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF WORKED MICA IN 1994, BY COUNTRY 1/

Country	Plates, sheets		Other	
	Quantity (metric tons)	Value (thousands)	Quantity	Value (thousands)
Argentina	--	--	13	$33
Austria	--	--	1	31
Belgium	668	$5,720	--	--
Brazil	22	1,080	270	559
Canada	(2/)	8	27	56
China	200	469	--	29
France	27	194	--	--
Germany	7	355	14	212
Hong Kong	1	4	--	--
India	24	427	59	735
Indonesia	2	2	--	--
Ireland	--	--	(2/)	6
Japan	8	99	5	1,110
Korea, Republic of	--	--	23	46
Spain	4	23	--	--
Switzerland	79	1,720	(2/)	2
Taiwan	(2/)	5	1	16
United Kingdom	(2/)	8	--	--
Total	1,040	10,100	415	2,830

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 13
SUMMATION OF U. S. MICA TRADE DATA

	Scrap and flake mica				Sheet mica			
	Powder		Waste		Unworked		Worked	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands
Exports:								
1993	4,610	$2,600	335	$99	292	$511	617	$9,020
1994	5,840	3,040	672	194	256	410	747	12,300
Imports for consumption:								
1993	13,100	8,070	4,770	1,310	2,960	2,520	1,350	9,340
1994	16,300	10,600	6,330	1,840	1,150	1,740	1,460	12,900

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 14
MICA: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country3/	1990	1991	1992	1993	1994 e/
Argentina:					
Sheet	226 r/	610 r/	373 r/	720 r/	720
Waste, scrap, etc.	638 r/	1,040 r/	635 r/	1,230 r/	1,230
Brazil e/	5,000	5,080 4/	7,000 r/	5,000	5,000
Canada e/	16,000	17,000	17,500	17,500	17,500
France e/	7,000	6,000	12,000 4/	8,000	8,000
India:					
Crude	3,860	3,610	3,500 e/	2,080 r/	3,000
Scrap and waste	2,820	1,920	2,000 e/	1,600 e/	1,600
Total	6,680	5,530	5,500 e/	3,680 r/ e/	4,600
Iran 5/	1,350	4,140	7,850	8,000 e/	8,000
Korea, Republic of (all grades)	4,770	5,130	7,730	7,500 e/	7,600
Madagascar (phlogopite)	721	680	798	774 e/	774
Malaysia	3,340	3,520	4,750	4,660	4,990 4/
Mexico (all grades)	5,860	5,590	5,870	6,440 r/	7,060 4/
Morocco e/	1,500	1,500	1,500	1,500	1,500
Peru e/	100	100	100	100	100
Russia e/	XX	XX	35,000	30,000	25,000
Serbia and Montenegro	XX	XX	281 r/	68 r/	75
South Africa, Republic of (scrap)	1,770	1,880	2,080 r/	1,990 r/	1,970 4/
Spain e/	913 4/	300	200 r/	250	200
Sri Lanka (scrap) e/	200	200	200	200	200
Taiwan	4,950	8,600	11,000	9,750 r/	10,000
Tanzania (sheet)	(6/)	(6/)	(6/)	(6/)	(6/)
U.S.S.R. (all grades) e/ 7/	45,000	40,000	XX	XX	XX
United States (scrap and flake) 8/	109,000	103,000	85,300	87,900	109,000 4/
Yugoslavia 9/	802	800	XX	XX	XX
Zimbabwe	1,300	506	495	500	213
Grand total	217,000 r/	211,000 r/	206,000 r/	196,000 r/	214,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 19, 1995.

3/ In addition to the countries listed, China, Norway, Pakistan, Romania, and Sweden are known to produce mica, but available information is inadequate to make reliable estimates of output levels.

4/ Reported figure.

5/ Data are for Iranian year beginning Mar. 21 of that stated.

6/ Less than 1/2 unit.

7/ Dissolved in Dec. 1991.

8/ Excludes U.S. production of low-quality sericite and sheet mica, if any.

9/ Dissolved in Apr. 1992.

MOLYBDENUM

By John W. Blossom

Molybdenum is a refractory metallic element used principally as an alloying agent in steels, cast irons, and superalloys to enhance hardenability, strength, toughness, and wear and corrosion resistance. Primarily added in the form of molybdic oxide or ferromolybdenum, it is frequently used in combination with chromium, columbium, manganese, nickel, tungsten, or other alloy metals to achieve desired metallurgical properties. The versatility of molybdenum has ensured it a significant role in contemporary technology and industry, which increasingly require materials that are serviceable under higher stresses, greater temperature ranges, and more corrosive environments. Moreover, molybdenum finds significant usage as a refractory metal in numerous chemical applications, including catalysts, lubricants, and pigments. The variety of uses for molybdenum materials, few of which afford acceptable substitutions, has resulted in a demand that is expected to grow at a greater rate than most other ferrous metals.

Distribution of molybdenum reserves and productive capacity is concentrated in a few countries of the world. World mine output was an estimated 104,000 metric tons (molybdenum contained in concentrate) in 1994, of which Canada, Chile, China, and the United States provided 86%. These four countries, led by the United States, are expected to continue as the principal mine producers for the rest of this century. These countries also possess about 90% of the estimated 12 million metric tons of molybdenum in world reserve base.

The metric system is the official system of measurement of most countries. The U.S. Bureau of Mines (USBM), in an effort to provide statistical data on molybdenum that are consistent with international usage, reports data in kilograms and metric tons.

Domestic production data for molybdenum are developed by the USBM by means of three separate, voluntary surveys. These surveys are Molybdenum Ore and Concentrate, Molybdenum Concentrate and Molybdenum Products, and Molybdenum Concentrates. Surveys are sent to all operations that produce molybdenum ore and products. Out of 10 operations to which surveys were sent, all responded, representing 100% of the total U.S. production shown in table 1.

Domestic mine production of molybdenum concentrate increased to a total of 46,800 tons of contained molybdenum compared with 36,800 tons in 1993. This production was about 45% of world production. World mine production of molybdenum concentrate increased from a total of 93,600 tons in 1993 to 104,000 tons in 1994. Canada, Chile, China, Russia, and the United States accounted for an estimated 86% of the molybdenum produced worldwide. Production of molybdenum products increased 37% in 1994. *(See tables 1, 2, and 3.)*

Consumption

Consumption of molybdenum concentrate increased 3,400 tons in 1994. Domestic mine production of molybdenum concentrate was either roasted, exported for conversion, or purified to lubrication-grade molybdenum disulfide. The consumption in 1994 of technical-grade molybdic oxide increased about 11% from that of 1993. Oxide is the chief form of molybdenum utilized by industry, particularly in stainless and alloy steel, cast iron, and superalloys. However, some of the material is also converted to other molybdenum products, such as ferromolybdenum, high-purity oxide, ammonium and sodium molybdate, and metal powder. *(See table 4.)*

Stocks

Total industry stocks, which include those of producers and consumers, decreased by about 8,400 tons of contained molybdenum. Inventories of molybdenum in concentrate at producer locations decreased about 5,690 tons. Producer stocks of molybdenum in products, such as oxide, ferromolybdenum, molybdate, metal powders, and other types, decreased by about 2,210 tons. Domestic end-use consumer stocks of molybdenum decreased 400 tons from that in 1993. Inventories of 2,100 tons represented approximately a 7-week supply as measured by the average monthly reported consumption.

Prices

Prices are from Platt's Metals Week and are in U.S. dollars per kilogram of contained molybdenum. The prices at the beginning of 1994 were: molybdenum concentrates (MoCons), $3.803; molybdic oxide (MoX), $6.025; and ferromolybdenum (Femo), $7.496. The prices at the beginning of the second quarter were: MoCons, $3.803; MoX, $6.746; and Femo, $8.230. The prices at the start of the third quarter were: MoCons, $6.008; MoX, $7.716; and Femo, $9.425. The prices at the start of the fourth quarter were: MoCons, $8.157; MoX, $10.280; and Femo, $10.748. The prices at the end of the fourth quarter were: MoCons, $8.708; MoX, $32.077; and Femo, $29.321. The average prices for 1994 were: MoCons, $2.531; MoX, $4.604; and Femo, $5.134.

Foreign Trade

Exports of molybdenum in concentrate and in molybdic oxide increased about 19% when compared with those of 1993. Molybdenum concentrate exports were about 72% of domestic mine production. Approximately 92% of reported exports of concentrate and oxides were made to Belgium, Canada, Chile, Japan, the Netherlands, and the United Kingdom. The calculated molybdenum content of all exports was about 38,600 tons in 1994. Total value of exports increased from $108 million in 1993 to $247 million in 1994.

Approximately 7,200 tons of molybdenum in various forms was imported into the United States, about the same as in 1993. Total value of all forms of molybdenum imported increased from $48 million in 1993 to $59 million in 1994. In terms of both value and quantity, the major form imported was ferromolybdenum. *(See tables 5, 6, and 7.)*

World Review

Capacity.—The rated capacity for mines and mills as of December 31, 1994, was 125,000 tons per year of contained metal. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Mine capacity for molybdenum is based on published reports, production statistics, and estimates.

Reserves.—The definitions of reserves and reserve base are published in U.S. Geological Survey Circular 831, "Principles of a Resource/Reserve Classification For Minerals," which is reprinted in the USBM Mineral Commodity Summaries, 1991.

The United States, with a reserve base of molybdenum estimated at 11.8 million tons, has 45% of the world molybdenum reserve base. About 90% of U.S. reserves occur in large porphyry or disseminated deposits mined, or anticipated to be mined, primarily for molybdenum. These deposits are in Alaska, Colorado, Idaho, Nevada, New Mexico, and Utah. Other molybdenum sources contribute insignificantly to U.S. reserves.

Canadian reserves of primary molybdenum are in British Columbia, including 30% of the total in the Endako primary deposit. Other Canadian reserves are associated with molybdenum and copper-molybdenum porphyry deposits in British Columbia and in relatively minor sources in Quebec and New Brunswick.

Molybdenum reserves in Central and South America are mainly in large copper porphyry deposits. Of several such deposits in Chile, the Chuquicamata and El Teniente deposits are among the world's largest and account for 85% of total molybdenum reserves in Chile. Mexico and Peru have substantial reserves. The La Caridad deposit in Mexico is a large producer. Numerous other copper porphyries that may contain recoverable quantities of molybdenum have been identified in Central and South America. Many of these deposits are actively being explored and evaluated and could add substantially to reserves in the future.

Reserves of molybdenum in China and the former U.S.S.R. are estimated to be substantial, but definitive information about the current sources of supply or prospects for future development in the two countries is lacking. Copper ores are being investigated on the islands of New Guinea and Bougainville in the southwest Pacific, but it is not known whether these contain economically recoverable molybdenum.

Outlook

The world demand for molybdenum contained in alloy and stainless steel and also for chemicals/catalysts is expected to increase 4% to 6% in 1995. It is estimated that the growth in demand will drop to 3% to 5% in 1996. Projecting into 1997, molybdenum demand may see a growth of 6% to 8%.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Molybdenum. Ch. in Minerals Commodity Summaries, annual.
Molybdenum. Ch. in Minerals Yearbook, annual.
Molybdenum. Reported monthly and annually in Mineral Industry Surveys.

Other Sources

American Bureau of Metal Statistics. Nonferrous Metal Data.
American Metal Market (daily paper).
Canadian Mining Journal (Canada). Annual reports of various companies.
Engineering and Mining Journal.
Metal Bulletin (London).
Metals Week.
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Mining Engineering.
Mining Journal (London).
Skillings' Mining Review.
The Northern Miner (Canada).

TABLE 1
SALIENT MOLYBDENUM STATISTICS 1/

(Metric tons of contained molybdenum unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Concentrate:					
Production	61,600	53,400	49,700	36,800	46,800
Shipments	61,600	53,600	45,100	39,200	46,000
Value thousands	$346,000	$250,000	$190,000	$165,000	$284,000
Reported consumption	35,500	33,000	15,200	13,800	17,200
Imports for consumption	478	161	831	3,400	2,280
Stocks, Dec. 31:					
Concentrate, mine and plant	7,670	5,290	11,900	11,200 r/	5,510
Product producers 2/	5,920	9,420	7,480	6,150	3,940
Consumers, by end use	2,580 r/	2,590	2,500	2,520	2,080
Total	16,200	17,300	21,900	19,900 r/	11,500
Primary products:					
Production	28,800	33,700	26,000	22,700	31,100
Shipments	18,000	19,100	17,300	16,000	21,400
Reported consumption, by end use	18,100	16,900	17,200	17,700	19,100
World: Mine production	127,000	115,000	108,000	93,600 r/	104,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes technical and purified molybdic oxide, briquets, ferromolybdenum, phosphomolybdic acid, molybdenum disulfide, molybdic acid, ammonium molybdate, sodium molybdate, calcium molybdate, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

TABLE 2
PRODUCTION, SHIPMENTS, AND STOCKS OF MOLYBDENUM PRODUCTS IN THE UNITED STATES 1/

(Metric tons of contained molybdenum)

	1993	1994	1993	1994	1993	1994
	Metal powder		Other 2/		Total	
Received from other producers	--	--	4,320	4,030	4,320	4,030
Gross production during year	1,580	2,570	21,100	28,600	22,700	31,100
Molybdenum products used to make other products	286	1,500	10,400	13,600	10,700	15,100
Net production	1,290	1,070	10,700	14,900	12,000	16,000
Shipments	419	214	15,600	21,200	16,000	21,400
Producer stocks, Dec. 31	101	124	6,050	3,820	6,150	3,940

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes ferromolybdenum, molybdic oxides, phosphomolybdic acid, molybdenum disulfide, molybdic acid, ammonium molybdate, calcium molybdate, sodium molybdate, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

TABLE 3
MOLYBDENUM: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of contained molybdenum)

Country 3/	1990	1991	1992	1993	1994 e/
Armenia e/	XX	XX	1,000	500	500
Bulgaria e/	150	120	120	120	100
Canada	12,000	11,300	9,410	9,700 r/	9,540 4/
Chile	13,600 r/	14,400	14,800	14,900 r/	16,000 4/
China e/	15,700	13,200	19,200 r/	18,300 r/	17,500
Iran	542	395	847 r/	1,000 r/ e/	1,000
Kazakhstan e/	XX	XX	700 r/	600 r/	500
Korea, Republic of	103	144	--	--	--
Mexico	2,000 e/	1,720	1,460	1,710	2,610 4/
Mongolia	1,580	1,720	1,520	1,500 e/	1,500
Niger e/	10	10	--	--	
Peru	2,510	3,030	3,220	2,980 r/	3,000
Russia e/	XX	XX	5,000	4,800	4,500
U.S.S.R. e/ 5/	17,000	16,000	XX	XX	XX
United States	61,600	53,400	49,700	36,800	46,800 4/
Uzbekistan e/	XX	XX	700 r/	700 r/	700
Total	127,000	115,000	108,000	93,600 r/	104,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 13, 1995.

3/ In addition to the countries listed, North Korea, Romania, and Turkey are believed to produce molybdenum but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.

4/ Reported figure.

5/ Dissolved in Dec. 1991.

TABLE 4
U.S. REPORTED CONSUMPTION OF MOLYBDENUM, BY END USE 1/

(Kilograms, contained molybdenum)

End use	Molybdic oxides	Ferro-molybdenum 2/	Ammonium and sodium molybdate	Molybdenum scrap	Other 3/	Total
1993						
Steel:						
Carbon	659,000	175,000	--	--	68,300	902,000
Stainless and heat-resisting	2,840,000	210,000	--	--	57,600	3,100,000
Full alloy	2,380,000	1,120,000	--	--	13,100	3,510,000
High-strength low-alloy	451,000	346,000	--	--	--	798,000
Tool	597,000	W	--	--	8,240	605,000
Cast irons	83,000	739,000	--	--	14,600	837,000
Superalloys	W	W	--	--	889,000	889,000
Alloys:				--		
Welding materials (structural and hard-facing)	--	93,900 r/	--	--	6,380	100,000
Other alloys 4/	W	W	--	--	54,100 r/	54,100 r/
Mill products made from metal powder	--	--	--	--	1,760,000	1,760,000
Chemical and ceramic uses:				--		
Pigments	W	--	W	--	--	W
Catalysts	1,650,000	--	W	--	179,000	1,830,000
Other	W	(5/)	W	--	315,000	315,000
Miscellaneous and unspecified	1,080,000	415,000	1,420,000	--	96,600	3,020,000 r/
Total	9,740,000	3,100,000	1,420,000	--	3,460,000	17,700,000
1994						
Steel:						
Carbon	668,000	303,000	--	--	76,900	1,050,000
Stainless and heat-resisting	3,310,000	537,000	--	--	43,300	3,890,000
Full alloy	2,460,000	1,180,000	--	--	31,300	3,670,000
High-strength low-alloy	518,000	307,000	--	--	--	825,000
Tool	788,000	W	--	--	W	788,000
Cast irons	199,000	773,000	--	--	14,200	986,000
Superalloys	W	W	--	W	618,000	618,000
Alloys:						
Welding materials (structural and hard-facing)	--	88,200	--	--	6,900	95,100
Other alloys 4/	W	W	--	--	74,200	74,200
Mill products made from metal powder	W	W	--	--	1,630,000	1,630,000
Chemical and ceramic uses:						
Pigments	W	--	W	--	--	W
Catalysts	1,710,000	--	W	--	179,000	1,890,000
Other	W	--	W	--	299,000	299,000
Miscellaneous and unspecified	1,100,000	258,000	1,280,000	481,000	158,000	3,280,000
Total	10,800,000	3,440,000	1,280,000	481,000	3,130,000	19,100,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes calcium molybdate.

3/ Includes purified molybdenum disulfide, molydenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal, pellets and other molybdenum materials.

4/ Includes magnetic and nonferrous alloys.

5/ Revised to zero.

TABLE 5
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY 1/

Product and country	HTS NO.	1993		1994	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Oxides and hydroxides, gross weight:	2825.70.0000				
Belgium		154	$720	164	$787
Brazil		--	--	34	168
Canada		199	1,330	414	3,330
China		--	--	183	429
India		--	--	38	154
Japan		525	2,850	505	3,380
Korea, Republic of		17	77	--	--
Mexico		--	--	10	278
Netherlands		77	353	558	3,330
Netherlands Antilles		--	--	109	821
United Kingdom		47	155	225	1,030
Venezuela		23	124	(2/)	9
Total		1,040	5,610	2,240	13,700
Molybdates all, contained weight:	2841.70.0000				
Canada		526 r/	2,460	437	2,200
Honduras		2	15	5	33
Indonesia		7	16	--	--
Jamaica		1	6	1	8
Japan		152	726	156	751
Korea, Republic of		110	512	113	552
Mexico		73	315	45	300
Netherlands		38	482	779	5,170
Netherlands Antilles		--	--	178	658
Pakistan		2	15	--	--
Philippines		(2/)	6	12	18
Singapore		2	11	1	9
Taiwan		39 r/	177 r/	66	234
Thailand		(2/)	3	6	44
Other		6 r/	39 r/	3	15
Total		958	4,790 r/	1,800	10,000
Ferromolybdenum, contained weight: 3/	7202.70.0000				
Argentina		--	--	17	179
Canada		60	593	113	1,260
Japan		41	616	93	1,090
Malaysia		76	1,120	6	92
Mexico		20	239	152	1,350
Netherlands		--	--	56	452
Singapore		16	232	12	338
Taiwan		9	127	28	408
Venezuela		2 r/	32	2	26
Other		(4/)	(4/)	(2/)	6
Total		224	2,960	479	5,200
Powder, gross weight:	8102.10.0000				
Belgium		1	5	13	443
Brazil		8	118	3	106
Canada		5	189	7	231
France		4	145	14	432
Germany		5	249	7	391
India		15	247	16	268
Italy		1	51	1	58
Japan		11	324	11	232
Mexico		16	399	9	284
Netherlands		1	32	3	117
Spain		(2/)	49	2	123
Sweden		18	286	5	77
Switzerland		(2/)	37	5	110
Taiwan		72	1,350	66	1,250
Turkey		1	69	(2/)	12
United Kingdom		45	210	3	113
Other		(2/) r/	116 r/	3	78
Total		203 r/	3,760 r/	168	4,320

See footnotes at end of table.

TABLE 5 -- CONTINUED
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY 1/

Product and country	HTS No.	1993		1994	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Molybdenum unwrought, gross weight:	8102.91.0000				
Australia		1	$11	10	$102
Austria		--	--	38	598
Canada		7	87	23	403
France		9 r/	163	4	117
Germany		5	33	--	--
Hong Kong		--	--	6	72
India		4 r/	56	2	22
Japan		1	12	85	1,050
Korea, Republic of		--	--	3	51
Mexico		(2/)	6	1	35
Netherlands		25	423	170	2,020
Netherlands Antilles		--	--	36	290
Sweden		--	--	9	71
United Kingdom		(2/)	3	9	141
Other		(2/) r/	5 r/	(2/)	15
Total		52	801	396	4,980
Molybdenum wrought, gross weight:	8102.92.0000				
Brazil		(2/)	25	2	82
Canada		8 r/	393	9	409
France		24 r/	975	18	782
Germany		6	484 r/	3	283
India		(2/)	46	1	114
Italy		1	47	1	80
Japan		14	1,280	34	2,510
Korea, Republic of		(2/)	59	2	220
Mexico		3	87	1	125
Netherlands		1	135	1	20
United Kingdom		31	1,060	26	1,190
Other		4 r/	202 r/	3	245
Total		94 r/	4,790	103	6,050
Wire, gross weight:	8102.93.0000				
Argentina		2	66	3	130
Belgium		1 r/	52	1	50
Brazil		24 r/	947	21	744
Canada		5 r/	176 r/	2	105
Czech, Republic		--	--	3	85
France		17 r/	606 r/	25	911
Germany		61 r/	1,990	51	1,890
Hungary		27	1,050	31	1,790
India		14	720	11	673
Italy		14	526	13	544
Japan		38 r/	1,510	12	747
Korea, Republic of		16	737 r/	14	621
Mexico		11 r/	519	6	501
Netherlands		--	--	1	14
Poland		--	--	1	47
Singapore		6	234	3	102
Spain		3	110 r/	5	155
Sweden		3 r/	112 r/	5	162
Taiwan		5 r/	235	7	301
United Kingdom		4	168	5	239
Other		12 r/	453 r/	2	234
Total		261 r/	10,200 r/	221	10,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Ferromolybdenum contains about 60% to 65% molybdenum.

4/ Revised to zero.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING ROASTED AND OTHER CONCENTRATES), BY COUNTRY 1/

(Metric tons)

Country	1993		1994	
	Quantity (contained molybdenum)	Value (thousands)	Quantity (contained molybdenum)	Value (thousands)
Argentina	--	--	1	$6
Australia	61	$284	23	118
Austria	--	--	11	80
Belgium	6,930	6,620	11,500	78,300
Brazil	218	816	445	3,030
Canada	403	1,790	1,300	7,070
Chile	2,960	8,240	2,160	11,900
China	--	--	224	800
France	294	1,030	--	--
Germany	1,500	5,040	635	3,820
India	2	54	127	781
Italy	--	--	78	640
Japan	4,030	13,000	3,860	24,800
Korea, Republic of	--	--	7	41
Malta	--	--	53	198
Mexico	12	112	519	6,410
Netherlands	9,990	28,200	8,670	35,300
Netherlands Antilles	--	--	554	2,910
Russia	--	--	53	1,160
Singapore	--	--	2	13
Sweden	874	2,540	107	581
Switzerland	--	--	16	249
United Kingdom	976	5,580	3,290	21,000
Other	32	929	--	--
Total	28,300	74,200	33,600	199,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF MOLYBDENUM 1/

Item	HTS No.	1993			1994		
		Gross weight (metric tons)	Contained molybdenum	Value (thousands)	Gross weight (metric tons)	Contained molybdenum	Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	5,800	3,370	$16,800	3,110	1,870	$12,700
Molybdenum ore and concentrates, other	2613.90.0000	40 r/	25	172	682	411	3,190
Molybdenum oxides and hydroxides	2825.70.0000	622	NA	2,880	628	NA	3,950
Molydates of ammonium	2841.70.0000	538	300	2,610	608	321	2,340
Molybdates all others	2841.70.5000	18 r/	17	28	76	41	288
Molybdenum orange	3206.20.0000	680	NA	2,040	616	NA	1,880
Mixtures of inorganic compounds	3823.90.3400	19	(2/)	154	3	2	235
Ferromolybdenum	7202.70.0000	3,480	2,190	12,700	4,590	2,960	23,200
Molybdenum powders	8102.10.0000	66	52	2,090	113	89	2,770
Molybdenum unwrought	8102.91.1000	164	136	1,750	70	52	1,060
Molybdenum waste and scrap	8102.91.5000	380	363	2,600	791	777	6,560
Molybdenum wrought (includes bars, rods, profiles, plate, sheets, strips, foil)	8102.92.0000	49	NA	3,430	--	--	--
Molybdenum wire	8102.93.0000	3	NA	308	2	NA	304
Molybdenum other	8102.99.0000	1	NA	759	5	NA	738
Total		11,900	6,460	48,300	11,300	6,520	59,300

r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

NICKEL

By Peter H. Kuck

The nickel supply picture changed drastically when a world class nickel-copper-cobalt deposit was delineated in October 1994 at Voisey Bay, Labrador. The near-surface sulfide deposit has at least 32 million metric tons (mt) of resources averaging 2.83% nickel (Ni), 1.68% copper (Cu), and 0.12% cobalt (Co). The Voisey Bay discovery, together with the modernization of operations at Sudbury, Ontario, and the launching of the Raglan Mine in northern Quebec, should keep Canada in the forefront of nickel suppliers far into the 21st Century. The discovery also has had a psychological effect on consumers, lessening their concerns about midterm shortages of nickel and encouraging use of the element in new applications.

Russia, the world's largest producer of nickel, continued to privatize and restructure all of its nickel mining and smelting operations. In 1994, RAO Norilsk Nickel accounted for 90.5% of total Russian production. Efforts were underway to modernize the Pechenga smelter on the Kola Peninsula. Scandinavian environmentalists have blamed the smelter—one of three operated by Norilsk—for much of the sulfur dioxide (SO_2) found in the air over Lapland. Russian officials have awarded the modernization contract to a Norwegian-Swedish engineering consortium. Groundbreaking was scheduled to begin in 1996. The Norwegian and Russian Governments have agreed to loan Norilsk Nickel almost one-half of the $258 million required for the project.

In December 1994, Sherritt, Inc., and the Government of Cuba formed a joint venture to refine and market nickel mined at Moa Bay. The joint venture immediately began drawing up plans to modernize the entire Moa Bay operation. The bulk of the sulfide precipitate was being shipped to Sherritt's refining complex at Fort Saskatchewan, Alberta.

The price of nickel metal on the London Metal Exchange (LME) gradually recovered, after bottoming out at a 6-year low in September 1993. The price rose steadily throughout 1994, spurred by increased production of stainless steel in the Far East and Western Europe. The price rise occurred in the face of substantial exports of both primary and secondary nickel from Russia. It also ran counter to the buildup of stocks in LME warehouses. LME stocks reached a record high of 151,254 mt on November 24, 1994. In less than a month, though, stocks began to drop off and continued to decline throughout the first half of 1995. In the last few years, financial institutions and commodity investment funds have become increasingly involved in the LME nickel market. Their speculative actions may account for the price paradoxes observed in 1994.

Mine development or expansion projects were underway in Manitoba, Ontario, Quebec, Brazil, Indonesia, New Caledonia, Venezuela, and Western Australia. In addition to Labrador, exploration teams were active in Cuba, Finland, Greenland, the Ivory Coast, South Africa, Russia, and Tanzania.

Apparent U.S. demand for primary nickel increased almost 10% between 1993 and 1994. U.S. demand for stainless steel was up even more substantially, with a large part of the increase being met by imports. Imports of hot-rolled plate, for example, were up 24%. Allegheny Ludlum, one of the larger U.S. stainless producers, was hamstrung by a 10-week strike. Several other stainless producers were in the midst of a restructuring and were unable to increase output. Stainless steel production has plummeted in Russia because of that country's ongoing economic restructuring. In other parts of the world, though, stainless production has been steadily growing. Capacity is being added in the Republic of Korea, South Africa, and Taiwan. Stainless steel now accounts for about 63% of primary nickel demand in the Western World.[1]

Demand for nickel by battery manufacturers also is growing, although the tonnages involved are an order of magnitude smaller than those for stainless steel. Rechargeable nickel-cadmium and nickel-metal hydride batteries are in strong competition with one another for hand-held powertools, laptop computers, cellular telephones, and camcorders. Peugeot SA of France was gearing up to produce electric vehicles (EV's) on an extended basis. The new vehicles were to be powered by nickel-cadmium batteries made by SAFT S.A.

Legislation and Government Programs

Cuban Embargo.—For more than 50 years, relations between Cuba and the United States have been intertwined with the island's nickel industry. In December 1994, the situation became even more complicated when Sherritt and the Cuban Government formed a joint venture to mine, refine and market nickel and cobalt from Moa Bay. The nickel-cobalt mining and processing complex at Moa Bay has been a particular source of contention between the U.S. and Cuban Governments. The Moa Bay facilities were expropriated without compensation from the Freeport Nickel Co. in August 1960. Freeport's successor, Freeport-McMoran Inc., continues to operate out of New Orleans, LA, and still holds claim to the complex, in Holguín Province.

The Cuban Government and Sherritt are equal partners in the Moa Bay venture. The day-to-day interests of the Cuban Government are handled by General Nickel (La Compania General de Niquel S.A.), a parastatal enterprise that also manages the Nicaro, Punta Gorda, and Las Camariocas nickel operations. Like Moa Bay, all three are in Holguín Province. General Nickel replaced Union Empresas del Niquel in 1994 and reports directly to the Ministry of Basic Industries. *(See Cuba section of this review.)*

The vertically integrated joint venture oversees three subsidiaries: Moa Nickel S.A., The Cobalt Refinery Company Inc., and The International Cobalt Company Inc. (ICCI). All three operate collectively as part of Sherritt's Commodity Metals business, but each is a separate 50-50 partnership between General Nickel and Sherritt.

The joint venture was formed to (1) provide a secure source of feed for Sherritt's Fort Saskatchewan refinery in Alberta, and (2) accelerate modernization and expansion of the Cuban nickel industry. None of the venture's production can be marketed in the United States because of the U.S. embargo against Cuba. Importation of Cuban nickel is prohibited under the Cuban Assets Control Regulations, 31 CFR, part 515.

Sherritt has stated that its three business units are operating in compliance with the laws of Canada, which has full economic and trade relations with Cuba. Company officials also believe that Sherritt is complying with applicable U.S. laws because the joint venture does not sell any of its products in the United States.

Environmental Regulations.—On September 19, 1994, the U.S. Environmental Protection Agency (EPA) set final universal treatment standards for a number of wastes that contain nickel mixed together with other regulated hazardous metals (e.g., beryllium, cadmium, chromium, or lead).[2] These wastes are part of a much larger group of wastes regulated under the Resource Conservation and Recovery Act (RCRA). EPA issued the new standards to eliminate confusion about the handling, treating, and disposal of wastes of different origins. The standards apply to "listed" wastes, and not to "characteristic metal" wastes, which have separate standards. Nickel-bearing wastes falling into the "listed" category include: Wastewater treatment sludges from electroplating operations (Waste code F006); Leachate [liquids that have percolated through land disposed wastes] (F039); and Emission control dusts and sludges associated with the production of steel in electric arc furnaces (K061).

On February 11, 1993, EPA proposed new streamlined regulations governing the collection and management of spent nickel-cadmium (Ni-Cd) batteries, mercury-containing thermostats, and certain other widely generated hazardous wastes. The agency solicited additional comments from the general public on June 20, 1994, and was to put the regulations (40 CFR part 273) into effect on May 11, 1995.[3] The new regulations are designed to encourage environmentally sound recycling of Ni-Cd batteries and keep them out of the municipal waste stream. No distinction is made on the basis of battery size, or between "wet" and "dry" batteries (i.e., batteries with liquid vs. nonliquid electrolytes). The package of regulations is known as the "Universal Waste Rule."

On February 2, 1994, the Ozone Transport Commission (OTC) petitioned EPA, requesting that New England and the Middle Atlantic States be allowed to follow California's lead on vehicular pollution-control standards. Adoption of the standards would help the northeastern United States comply with national ambient air quality standards. The OTC, established in 1991 under Section 184 of the Clean Air Act Amendments of 1990, is an interstate agency responsible for reducing ozone levels in the Northeast.

The California-style program would allow individual States in the region to mandate the sale of advanced technology vehicles (ATV's) if Federally legislated air quality goals cannot be met. Zero-emission vehicle sales mandates have been controversial and, in some cases, have led to litigation. The New York regulations have been upheld by the Courts, but the ones for Massachusetts were still being contested. EPA was to have ruled on the OTC petition by November 10, but let the deadline pass after receiving a deluge of comments. At the present time, only EV's can meet California's zero tailpipe emission requirement. California's program is to take effect in late 1997.

The OTC petition was important to the nickel industry because EV's powered by rechargeable nickel-based batteries could be used to meet part of the sales mandates proposed for those portions of the Northeast with the severest air pollution problems. The battery pack of a typical EV could conceivably contain 40 to 170 kilograms of nickel depending upon its design and battery chemistry.

Various State environmental agencies and automobile manufacturers have met in search of alternatives. The manufacturers have offered to begin selling cleaner, low-emission gasoline-powered vehicles nationwide by 1999. Industry representatives claimed that the "49-State Car" would satisfy all of the basic requirements of the Clean Air Act. Several compromises were proposed. One proposal called for State and Federal agencies to acquire EV's, vehicles that run on compressed natural gas, and other ATV's for their fleets. ATV's would be offered for sale at the retail level in the region beginning in 2002.[4]

Finally on December 19, EPA tentatively approved the OTC petition, allowing the 12 States and the District of Columbia to impose California-style limits on vehicle emissions.[5] The OTC was continuing its discussions with the automobile manufacturers in an effort to make the program better and more acceptable to the entire automobile industry.

Defense Stockpile Sales.—The Defense Logistics Agency (DLA) continued to sell nickel metal from the National Defense Stockpile (NDS). The Government had 33,760 mt of nickel in inventory when the sales started on March 24, 1993. The bulk of the material was purchased during the Korean War or the 5-year period immediately following the war. All 33,760 mt was cathode except for 399 mt contained in 520 mt of oxide of Cuban origin.

Nickel had been included in the stockpile since the beginning of World War II. In 1941, nickel was one of the first metals to be placed on a restricted-use basis. The metal was desperately needed to make gun steels and remained in short supply throughout the war. However, in October 1992 the Bush Administration, together with the Congress, decided that the Government no longer needed to hold nickel and authorized disposal of the entire inventory. The ongoing sales are part of a much larger downsizing of the stockpile approved under the Defense Authorization Act of 1992 (Public Law 102-484).

By the beginning of 1994, uncommitted stocks had shrunk to 31,182 mt. A total of 4,794 mt were turned over to purchasers in 1994, leaving uncommitted stocks of 25,470 mt on December 31. Total yearend stocks also included 1,287 mt of committed material. An additional 7,486 mt of cathode was auctioned off during the first 9 months of 1995. It will take at least 2 years to dispose of the remaining nickel at the currently authorized sales rate.

Production

The nickel mining and smelting complex near Riddle, OR, was idle all of 1994. The complex is owned and operated by the Glenbrook Nickel Co. — a 50-50 venture of Cominco American Inc. and Cominco Resources International Ltd. Glenbrook's management shut down the operation in August 1993 shortly after the LME cash price dropped below $2.50 per pound. However, when nickel prices recovered in late 1994, the company decided to resume production. Startup was scheduled for April

1995.[6]

The port facility at Coos Bay, the mine on Nickel Mountain, and the ferronickel smelter at the base of the mountain were all described in detail in a 1993 journal article by Kerry Spickelmier.[7] Glenbrook had been using lateritic ore from both New Caledonia and Nickel Mountain as feed. The New Caledonian ore imported in 1991-93 typically contained 2.2% to 2.4% Ni on a dry basis and was significantly richer than the 1.0% to 1.25% material being mined on Nickel Mountain. The recently renovated smelter has a capacity of 16,000 metric tons per year (mt/a) of Ni in ferronickel. The existing process requires ferrosilicon, but produces ferronickel with a considerably higher Ni content (48% to 52%) than most competing ferronickel products.

The International Metals Reclamation Co., Inc. (INMETCO) continued to produce nickel-chromium-iron alloy at its metals recovery facility in Ellwood City, PA. The facility was set up in 1978 to reclaim chromium and nickel from emission control dusts, swarf, grindings, and mill scale — all generated by the stainless steel industry. The plant later was modified to process filter cakes, plating solutions, spent Ni-Cd batteries, and a variety of other recyclable ferrous metal-bearing wastes. In 1993, INMETCO produced 22,196 mt of chromium-nickel-iron alloy from 58,000 mt of solid waste and 710,000 gallons of liquid waste. The 58,000 mt of solids included 1,900 mt of consumer and industrial Ni-Cd batteries.[8]

In May 1994, INMETCO acquired key cadmium recovery technology from Saft Nife AB. That same month, INMETCO awarded a contract to design and construct a full-scale cadmium recovery unit at Ellwood City. The new unit will allow cadmium metal to be recovered onsite, allowing more Ni-Cd batteries to be fed into the operation.

Consumption

Demand for primary nickel in the Western World grew substantially in 1994 and was estimated to be about 779,000 mt — an all time high.[9] The tonnage was about 15% more than the previous record of 674,000 mt set in 1993. U.S. apparent consumption of primary nickel was 134,000 mt, or about 17% of Western demand. U.S. industry consumed an additional 59,000 mt of nickel in scrap. Both U.S. and world demand continued to be driven by the stainless steel industry, which accounted for 38% of primary nickel demand in the United States and more than 60% of equivalent world demand. *(See tables 2 through 4 and figure 2.)*

Since 1991, major restructuring, adoption of more efficient work practices, and the introduction of new technology have improved the competitiveness of the U.S. stainless and specialty steel industry. Production of raw stainless and heat-resisting steel in the United States increased slightly to 1.83 million mt and was 3% more than the corresponding figure for 1993.[10] Nickel-bearing grades accounted for 1.20 million mt, or 65% of the production tonnage. Net shipments of all types of stainless totaled 1.56 million mt.[11] Shipments of sheets and strip rose 15% to 1,125,137 mt, breaking the record of 981,677 mt just set in 1993. This category has been steadily increasing since 1989. The next largest category was plate [flat product 4.8 millimeter (3/16 inch) or more in thickness]. Shipments of plate were 185,115 mt, 5% more than that of 1993. Together, plate and sheet accounted for 84% of total net shipments, compared with 83% in 1993.

On April 1, 1994, the United Steelworkers of America struck Allegheny Ludlum Corp., one of the larger stainless steel producers in the United States.[12] The strike lasted 10 weeks and idled 3,500 workers. Operations were crippled at six of the company's plants, including the melt shop at Brackenridge, PA. The strike ended on June 9, with steel shipments returning to normal levels by the fourth quarter.

The operations of Jessop Steel were successfully integrated into Allegheny Ludlum, despite the strike. Allegheny Ludlum acquired Jessop on November 10, 1993, as part of Allegheny Ludlum's buyout of Athlone Industries, Inc. Jessop's melt shop at Washington, PA, was closed and all of its melting work was transferred either to the nearby Brackenridge and Natrona meltshops or to Lockport, NY.[13]

In 1994, U.S. consumption of primary nickel in superalloys increased 6%, despite problems in the aerospace industry. Sales by the aerospace industry fell 9% to $113 billion.[14] Combined aircraft and missile purchases by the U.S. Department of Defense declined for the seventh consecutive year. Purchases of civil aircraft, engines, and parts by commercial airlines and foreign governments were down 22%. Jet engine manufacturers, significant consumers of nickel-chromium-cobalt and nickel-chromium-iron alloys, were working aggressively to cut costs. The Boeing Co. and McDonnell Douglas Corp. continued to work off a backlog of orders received between 1988 and 1990 for civil jet transport. However, this backlog has been steadily shrinking over the last 4 years. Only 79 net orders for large civil jet transports were received in 1994, compared with 309 shipped. On December 31, 1994, the two companies had a combined backlog of 1,126 aircraft, down from 1,356 at yearend 1993 and 2,138 at yearend 1990.

Domestic consumption data for nickel metal and its compounds are developed by the U.S. Bureau of Mines from a voluntary survey of U.S. operations. Sixty-four consumers participated in the Bureau's monthly canvassing program. An additional 123 consumers returned the 1994 annual survey forms, for a total response of 187. The consolidated consumption data are shown in tables 3 through 5.

Stocks

The combined stocks of primary nickel maintained in the United States by foreign producers and metal-trading companies with U.S. sales offices declined 35% during the year. At yearend, these stocks represented 28 days of apparent primary consumption. The stocks held by domestic consumers are given in table 5.

In recent years, LME stocks have far exceeded U.S. consumer stocks. On December 31, 1994, LME warehouses held 148,392 mt of nickel metal, of which 148,230 mt or 99.9% was in the form of cut cathodes. The remaining 0.1% consisted of briquets and a limited amount of pellets. The inventory on the 31st was less than 2% off the all-time record high of 151,254 mt reached a month before on November 24.

Although the LME has 18 warehouse sites scattered around the world that are authorized to hold nickel, most of the material is being stored in Rotterdam. The surge in exports from Russia caused stocks in Rotterdam to mushroom during 1994. At closing on November 24, the Rotterdam depots had 141,060 mt on warrant, or 93% of total

LME stocks. Two years earlier, on November 26, 1992, Rotterdam had 60,066 mt on hand, with stocks at all of the remaining LME locations totaling only 2,610 mt.

Prices

Nickel prices gained considerable ground between mid-1993 and the end of 1994. *(See figure 1.)* In the summer of 1993, the LME cash price was still under pressure from lingering recessionary forces in Japan, the United States, and Western Europe. For more than 2 years, the nickel supply in the Western World had significantly exceeded demand, gradually forcing prices downward. Russian stainless production had plummeted and the value of the ruble was shrinking, encouraging Norilsk Nickel to export the bulk of its nickel production to the West. At this point, market forces forced prices further downward. The LME cash price finally bottomed out on September 30, 1993, hitting a 6-year low of $4,012 per mt ($1.820 per pound) for the day.

Prices slowly improved during the winter of 1993 as demand for stainless steel began to pick up. By the beginning of 1994, prices had partially recovered and were still rising. The average LME cash price for the first week in January was $5,215 per mt ($2.365 per pound). Prices continued to climb throughout the spring of 1994. On May 27, the weekly average reached $6,462 per mt ($2.931 per pound). Prices took a small downturn in August, but quickly recovered and resumed their climb. The last weekly price (for the week ending December 30) was $8,742 per mt ($3.965 per pound). The average annual price for 1994 was $6,340 per mt ($2.876 per pound). This was almost 20% higher than the 1993 average of $5,293 per mt ($2.401 per pound).

Prices did not peak until late January 1995. The average cash price for the week ending January 27 was $10,072 per mt ($4.569 per pound). Since then, prices have been volatile, fluctuating between $6,900 and $9,800 per mt of nickel ($3.13 and $4.45 per pound). Some analysts attributed the volatility to the increasing role being played in the nickel futures market by commodity funds, financial institutions, speculators, and other segments of the investment community.

Foreign Trade

U.S. net import reliance as a percentage of apparent consumption was 64% in 1994. The figure was slightly higher than the 1993 percentage because of the extended shutdown of the Glenbrook smelter and a 16% increase in imports of ferronickel. Imports accounted for almost 100% of primary supply in 1994, if Government stockpile sales are excluded. *(See tables 8 and 9.)* Canada, as usual, supplied most of the imported material. A significant part of the nickel imported from Norway, the second largest source, was also of Canadian origin.

U.S. imports of Russian cathode dropped 30% between 1993 and 1994. In 1994, the United States imported 4,659 mt of cathode and 640 mt tons of powder and/or flake directly from Russia. Importers also brought in 790 mt of Russian nickel contained in ferronickel and 27 mt contained in primary chemicals. These figures do not include material that may have been recovered in Norway from Russian matte and later exported to the United States.

Increased demand for stainless steel in the Far East and Western Europe caused prices for both primary nickel and nickel-bearing scrap to rise worldwide. As a result, U.S. exports of stainless steel scrap rose 26% between 1993 and 1994. Most of the additional tonnage went to meltshops in the European Union. Exported stainless scrap contained an estimated 22,396 mt of Ni, up from 17,849 mt in 1993. These figures are based on the assumption that stainless scrap has been averaging 7.5% Ni since 1989, when the changeover to the Harmonized Tariff System took effect. *(See tables 6 and 7.)*

On September 8, 1994, the U.S. International Trade Commission (ITC) launched an investigation of Japanese-made nickel/metal hydride (Ni-MH) anode materials and batteries. In August, the Ovonic Battery Co., Inc. (OBC) and Energy Conversion Devices, Inc. petitioned the ITC to bar the importation and sale of Ni-MH batteries from Japan, claiming that the major Japanese battery manufacturers were infringing on OBC's patent (U.S. Letters Patent 4,623,597) — violating section 337 of the Tariff Act of 1930.

OBC is a subsidiary of Energy Conversion Devices; both companies are in Troy, MI. The complaint named three prominent Japanese companies together with their U.S. subsidiaries: Sanyo Electric Co. Ltd. of Hyogo, Toshiba Battery Co. Ltd. of Tokyo, and Yuasa Corp. of Tokyo.

Rechargeable Ni-MH batteries are being increasingly used in portable consumer electronics, such as laptop computers, pagers, cellular telephones, and video cameras. According to some industry experts, the market for Ni-MH consumer batteries is growing at more than 15% per year.

World Review

Australia.—Western Mining Corp. Holdings Ltd. (WMC), one of the four largest nickel producers in the Western World, continued to expand production capacity. At the end of 1994, the company was ready to start up its new Mount Keith Mine. The open pit operation is in the Greenstone Belt of Western Australia, about 90 kilometers (km) north of Agnew. Today, the $320 million complex is one of the larger metal mines in Australia.

WMC was planning to extract 210 million mt of ore, averaging 0.58% Ni, from Mount Keith over the next 20 years. The on-site concentrator is designed to handle 18,000 mt of sulfide ore per day, which equates to about 28,000 mt/a of Ni in concentrate.

Construction crews have been on-site since March 1993. Over 75% of the construction work on the concentrator and associated infrastructure had been completed by June 1994.[15] At that point in time, the open pit was more than 60 meters (m) deep, exposing part of the orebody. The principal contractor was Leighton Holdings Ltd., a construction and civil engineering company based in New South Wales. Between 700 and 1,000 construction workers were employed on the project in late 1994. However, only 231 employees will be needed to operate the mining complex.

The concentrator was commissioned in December and began shipping concentrates a month later. Half of the concentrate was to go to WMC's smelter at Kalgoorlie; the rest, to the Harjavalta smelter of Outokumpu Oy in Finland. WMC also recently upgraded and expanded both its Kalgoorlie smelter and Kwinana refinery.

Anaconda Nickel NL was in the early stages of evaluating the Murrin Murrin deposit.[16] The deposit is about 150 km southeast of Agnew in Western Australia. BHP Engineering Pty. Ltd., Sherritt, and H. A. Simons Ltd. of Vancouver, BC, have agreed to participate in the prefeasibility studies. According to Anaconda officials, the deposit has at least 66 million mt of lateritic ore grading about 1.14% Ni and 0.07% Co. A pressure acid-leaching plant would be built on-site to extract the nickel and cobalt directly from the ore. The Murrin Murrin operation would produce 31,000 mt/a of nickel and 2,500 mt/a of cobalt.

In March, the Government of Western Australia approved the construction of a 1,380-km-long natural gas pipeline from Yarraloola on the northwest coast through the Pilbara to the nickel smelter at Kalgoorlie.[17] The pipeline would go through the Goldfields region and pass close to Wiluna, Mount Keith, and Leinster. On March 23, the Premier of Western Australia signed an agreement with the Goldfields Gas Transmission Joint Venture (GGTJV), setting conditions for nondiscriminatory third-party access to the gas and establishing key design parameters. GGTJV is a joint venture of WMC, BHP Minerals Pty. Ltd., and Normandy Poseidon Ltd. Most of the gas will come from the offshore Griffin or North Rankin gas fields on the North West Shelf. However, some may also come from the onshore Tubridgi field. Construction of the pipeline was to start in July 1995 and would take about a year to complete. Delivery of gas to Kalgoorlie was scheduled to begin in August 1996. The Government and consortium are hoping that the A$400 million pipeline will stimulate additional investment in the region's mining industry. Part of the gas would be available for mineral extraction and processing, encouraging existing metal producers along the route to build downstream processing facilities that would add value to their products. Cheaper energy could spur development of Bulong, Anaconda, and several other nickel laterite deposits.[18]

Brazil.—RTZ Corp. was planning to spend $233 million to develop the Fortaleza deposit in the State of Minas Gerais.[19] RTZ acquired the rights to the site in 1989 as part of a packaged purchase of projects from British Petroleum. An open pit mine would be developed first, followed by an underground complex. The nickel-copper-cobalt sulfide concentrates would be smelted on-site using the flash smelting process developed by Outokumpu Oy. An adjoining electrolytic refinery would produce about 10,000 mt/a of cathode. The bulk of the cathode would go to the Brazilian stainless steel industry.

Canada.—In September 1993, an exploration team working for Diamond Fields Resources Inc. discovered significant nickel-copper-cobalt mineralization in a remote area of the Labrador coast at a point west of Voisey Bay. Initial core drilling of the prospect in late 1994 revealed a massive sulfide ore body more than 100 m thick. The Voisey Bay deposit reportedly is the largest base metal discovery in Canada in more than 30 years. The discovery site is 35 km southwest of the town of Nain and about 350 km northwest of Goose Bay.

Up until the discovery, Diamond Fields had been a small mining company exploring primarily for diamonds. The company had done little work in northern Labrador — most of its experience being in southern Africa, Sierra Leone, and the Northwest Territories. Diamond Fields is headquartered in Vancouver, BC.

Less than 1% of the 1,800 square kilometers (km^2) of claims has been drilled to date. Although the massive sulfide deposit is in a remote part of northeastern Labrador, it is only 10 km from a natural deep-water harbor. The deposit lies close to the surface, permitting inexpensive open pit mining.

Exploration geologists became interested in the site after identifying an electromagnetic and magnetic geophysical anomaly in an area riddled with large sills and dikes. The anomaly is at least 7 km in length. The four discovery holes (VB-94-01 to 04) penetrated a thick east-west trending gabbroic dike containing disseminated, semimassive, and massive sulfide mineralization. The best of the four holes (VB-94-02) reportedly intersected 71 m of ore assaying 2.23% Ni, 1.47% Cu, and 0.123% Co.[20] Since then, additional geophysical surveying has revealed that the anomaly widens to the east, where it takes on an ovoid shape. Crews were preparing to drill the ovoid feature at the beginning of 1995.

More than 160 holes have been drilled on the property since the original discovery. According to Teck Corp., which now holds a 10.4% interest in Diamond Fields, the near-surface deposit has at least 32 million mt of resources averaging 2.83% Ni, 1.68% Cu, and 0.12% Co.[21] If the preliminary findings are correct, Voisey Bay would be bigger and richer than Raglan. The ore body has a wine-glass shape in section and is roughly 450 m in length. In plan view, it is 300 m wide at its thickest point. An airborne geophysical survey was being conducted over the entire 1,800 km^2 of claims held by Diamond Fields and its lessor, Archaean Resources Ltd. Archaean will earn a 3% net smelter royalty. *(For additional information and detailed assay results, see references cited in footnotes 22, 23, and 24.)*

Falconbridge Ltd. has decided to develop its Raglan deposit at the northern tip of the Ungava Peninsula. Work was to begin as soon as ongoing negotiations with the Provincial Government of Quebec were completed. A few issues involving infrastructure funding, environmental permitting, and taxation still needed to be resolved. Falconbridge also had to finalize its agreement with the Makivik Corp., which represents the local Inuit people.[25]

Falconbridge was planning to spend C$486 million to bring the deposit into production by mid-1998. A sulfide concentrate would be produced on-site at Katinniq and trucked about 65 km to Deception Bay, PQ, where it would be transshipped by vessel to the company's smelter at Sudbury, ON. At Sudbury, the concentrate would be converted into matte. From Sudbury, the matte would go to the company's Nikkelverk refinery at Kristiansand, Norway. The capacity of the 64,000-mt/a Nikkelverk operation was being increased to 80,000 mt/a of Ni at a cost of C$31 million to handle the additional matte.

According to Falconbridge officials, the Raglan deposit has 18.1 million mt of reserves, averaging 3.13% Ni and 0.88% Cu. Of the 18.1 million mt, 4.5 million are proven. Falconbridge was planning to produce 20,000 mt/a of Ni in concentrate over the first 15 years of operation. The deposit was discovered in the 1930's but had been passed over on several occasions because of its extreme northern location. Falconbridge has had control of the property since 1966.

In October, Inco inaugurated a revolutionary facility at Sudbury that produces electrode substrates from nickel carbonyl. The new facility is located at the Copper Cliff nickel refinery and primarily will make nickel foam for rechargeable batteries, including batteries for EV's.

China.—On December 8, 1994, Inco announced that it had entered into a joint venture with Jinchuan Non-Ferrous Metals Corp. to produce nickel salts for the Asian market. Jinchuan is, by far, the largest nickel producer in China and accounted for 88% of the country's total nickel output in 1993. The parastatal company is a subsidiary of China National Non-Ferrous Metals Industry Corp. (CNNC). Jinchuan has been expanding its operations in Gansu Province and was capable of producing 40,000 to 50,000 mt/a of cathode in mid-1995.

The joint venture planned to construct a nickel chemical plant in the Shanghai area at a cost of about $10 million. Inco would have a 65% share in the venture; Jinchuan, 35%.[26]

Colombia.—In the fall of 1994, Gencor Ltd. acquired Billiton BV from the Royal Dutch/Shell Group, and with it, Billiton's 47% interest in the Cerro Matoso ferronickel operation. The remaining shares are held by Cia. de Niquel Colombiano S.A. (5%) and an agency of the Colombian Government — Instituto de Fomento Industrial (48%). The equity in Cerro Matoso was one of several lesser mining and smelting interests included in the sale of Shell's bauxite and aluminum holdings. The Billiton acquisition reportedly was part of Gencor's plan to focus on its core mining businesses and internationalize more of its holdings. Since 1993, Gencor has become increasingly involved with nickel because of its ties to the Columbus Stainless Steel Project and Impala Platinum Holdings Ltd. *(See section on South Africa.)*

In 1994, Cerro Matoso produced 20,833 mt of nickel contained in ferronickel bars and granules. The latest statistics released by the INSG indicate that the company exported 20,501 mt on a contained basis in 1994, 55% of which went to Europe.

Cuba.—On December 2, 1994, General Nickel of Cuba and Sherritt announced that they had formed a joint venture to mine, refine, and market nickel and cobalt. Negotiations between the two partners had been underway for more than 6 months.

General Nickel mines limonitic laterite ores in the eastern part of Holguín Province and, until the joint venture was formed, operated the nickel-cobalt processing plant at Moa Bay. The Government of Cuba endorsed the joint venture, which has three separate subsidiary corporations.

The first corporation, Moa Nickel S.A., became responsible for all of the mining and beneficiation operations at Moa Bay. However, Cuba's two other processing plants—Nicaro and Punta Gorda—are not part of the joint venture.[27] The second corporation, The Cobalt Refinery Co., runs the recently upgraded nickel-cobalt refinery at Fort Saskatchewan, Alberta. The refinery is now able to produce 25,000 mt/a of nickel in metal powder and briquets. The third corporation, ICCI, markets and sells the output of the Canadian plant in Europe and Asia. The Government of Cuba has granted the venture mining concessions with more than 60 million mt of limonitic ore. About 80% of these reserves are proven, according to Sherritt officials. The ore typically averages about 1.3% Ni, 0.1% Co, 3.7% SiO_2, and 64% Fe_2O_3 after drying. The concessions will allow the Moa plant to operate for at least 25 years. The Government also granted the venture more than 15,000 hectares of additional reserves which could extend the life of the operation to a total of 50 years.

The joint venture will spend approximately C$150 million (US$108 million) upgrading and expanding the Moa facilities. The Cuban plant was built for the Freeport Nickel Co. between 1957 and 1959 at a cost of $61.5 million and has been in almost continuous production since then. The Moa operation uses a pressurized acid leach process to extract the two metals and was producing about 13,000 mt/a of nickel in sulfide precipitates. The upgrading, expected to take 3 to 5 years, would raise the capacity of the operation to 24,000 mt/a. The process is relatively efficient, recovering more than 90% of the nickel, but consumes large amounts of sulfuric acid. The sulfuric acid is neutralized with coral mud midway through the process and converted to waste gypsum. Disposal of residual acid reportedly has created environmental problems for the Cubans. Sherritt was hoping to solve most of these problems with new proprietary technology developed by the company.

Sherritt was planning to invest at least $109 million to upgrade the facilities at Moa Bay. Roughly one-third of the money would be used to replace the three existing acid plants with a single modern unit. New materials handling equipment also was needed.[28]

In a related development, WMC agreed in principle to establish a joint nickel-cobalt venture in Cuba with Commercial Caribbean Nickel S.A. (CCN). The announcement was made by WMC's Board of Directors on September 21, 1994. The joint venture with the Cuban parastatal company would explore and, if commercially viable, develop the Pinares de Mayari West deposit. The laterite deposit, also in Holguín Province, reportedly contains at least 200 million mt of ore grading 1% Ni and 0.1% Co. WMC would earn a 65% share in the project by funding a delineation drilling program, metallurgical test work, and a feasibility study.

Gencor also signed a letter of intent with the Government of Cuba to evaluate and, if economically feasible, develop the San Felipe lateritic nickel deposit in central Camaguey Province.[29] A formal agreement establishing a joint venture was expected to be concluded in 1995. The San Felipe project would be the first nickel mining operation outside Holguín Province. The proposed joint venture also would be responsible for developing a nearby gold-copper deposit. Malecon Minerals & Metals Holdings Ltd., a wholly owned subsidiary of Gencor, would oversee both projects. Gencor would have a 75% interest in the proposed nickel project; the Cuban Government, 25%. The gold-copper project, though, would be a 50-50 venture.[30]

The director of Geominera S.A., a parastatal agency of the Cuban Government, told reporters in Havana that Gencor was prepared to invest more than US$300 million in developing both the nickel and gold deposits and constructing facilities for processing the two ores. Gencor reportedly has had exclusive rights to explore for both nickel and gold in the San Felipe district for some time. The crude output of nickel and cobalt would be refined outside Cuba.

The Cuban Government created Geominera so that the Government could enter more easily into joint ventures with foreign companies involved in exploration and mining. The parastatal company is part of the Ministry of Basic Industry. Parastatal joint ventures of this type have been permitted since the enactment of Legislative Decree No. 50 in February 1982.

Dominican Republic.—In 1994, Falconbridge Dominicana, C. por A., produced 30,800 mt of Ni in ferronickel.[31] More than 90% of the ferronickel was in the form of ferrocones, a product resembling a large metallic gumdrop and weighing about

125 grams. The new Loma Ortega Mine was in full production and was supplying about 15% of the feed for the Bonao smelter. Loma Ortega lies outside the original mining area and is about 50 km from the smelter.

Finland.—Outokumpu Metals & Resources Oy (OMR) was in the midst of a restructuring and decided to halt mining at its Vammala Mine in Turku-Pori Province because of declining ore reserves.[32] The Vammala Mine had been in operation since 1978 and produced 7.4 million mt of ore, averaging 0.69% Ni and 0.43% Cu. Most of the 60 employees at Vammala were reassigned to neighboring gold operations.

OMR has only one nickel mine still operating in Finland—the Hitura Mine near Ainastalo. According to company records, the Hitura Mine had 1.1 million mt of proven and probable reserves, averaging 0.66% Ni, at the end of 1994. The mine had an additional 4.47 million mt of indicated and inferred resources containing 0.81% Ni.

The Enonkoski Mine, OMR's third nickel operation, was officially closed in December 1994. The mine is near Karvila and Savonlinna in the southeastern part of Finland and was the largest of the three, with a capacity of 7,200 mt/a of nickel in concentrate. During its 9 years of operation, the Enonkoski Mine produced 6.7 million mt of ore, averaging 0.76% Ni and 0.22% Cu. The mine reportedly still has 0.61 million mt of reserves remaining, but they contain only 0.37% Ni and 0.10% Cu.

Outokumpu was in the process of expanding and modernizing its Harjavalta smelting and refining complex. The modernization will raise the production capacity of the complex to 32,000 mt/a of nickel briquets and cathode and 160,000 mt/a of blister copper. In 1994, Harjavalta produced 15,900 mt of nickel and 98,200 mt of blister copper. Nickel production costs were expected to drop 20% as a result of the improvements.

Both Finland and Russia are interested in promoting development in the sparsely populated Arctic. The Government of Finland was soliciting bids to develop the Kevitsa nickel-copper deposit in Lapland. The first round of bids was due on February 2, 1995. The Kevitsa deposit was discovered by the Finnish Geological Survey about 1991 near the town of Sodankyla. More than 300 exploratory holes have been drilled to date. The deposit covers at least 10 hectares (25 acres) and occurs in a ultramafic layered intrusion (mostly olivine pyroxenites) of Early Proterozoic Age. The Ni/Cu ratio ranges from about 0.6 to 0.9. Platinum group metals, gold, and cobalt also are enriched in the ore.

Indonesia.—In November 1994, P.T. International Nickel Indonesia (P.T. Inco) announced plans to increase the capacity of its mining and smelting complex on the island of Sulawesi by 50%. The expansion would take 5 years and cost $500 million. The annual capacity of the Soroako smelter would be raised from 45,400 mt of Ni in matte to about 68,000 mt. The expansion would involve installation of a fourth electric furnace at Soroako and construction of additional hydroelectric generating capacity at the company's powerplant on the Larona River.

P.T. Inco decided to move ahead with the expansion after the Government of Indonesia agreed in principle to extend P.T.'s Inco's contract of work beyond the year 2008. The contract of work extension was to have been submitted to the Indonesian Parliament for approval sometime in 1995. P.T. Inco currently has mining rights to 218,529 hectares (540,000 acres) of laterite on Sulawesi. Exploration since 1990 has identified additional resources southeast of Soroako, between Pomalaa and Torobulu. The Pomalaa East area contains at least 50 million mt of ore, averaging 1.9% Ni, and may constitute a possible resource of 147 million mt.[33]

P.T. Inco produced a record 45,325 mt of nickel in matte in 1994, up significantly from the 34,353 mt of 1993. The granulated matte averages 78% Ni and is shipped to the Tokyo Nickel Co., Ltd. in Japan for further refining.

P.T. Inco has been operating in Indonesia since 1968 and had 2,066 permanent employees at the end of 1994. An additional 1,100 people were working on-site either temporarily or for contractors. The two principal shareholders are Inco Ltd. of Canada (58.19%) and Sumitomo Metal Mining Co. Ltd. of Japan (20.09%). Another 20.00% is held by public shareholders. The remaining 1.72% is divided between Tokyo Nickel and four other Japanese companies.

Ivory Coast.—Falconbridge geologists were investigating several laterite deposits near Mount Nimba on the border with Liberia. To date, their work has focused on three prospects in the Biankouma-Sipilou concession. Together, the three prospects have 54 million mt of ore averaging 2.02% Ni and 0.07% Co.[34] The Sipilou North area has an additional 54 million mt of ore grading 1.80% Ni and 0.10% Co. Preliminary metallurgical tests indicate that ferronickel could be made from the West African ores using the Falcondo process presently employed in the Dominican Republic. The project is part of a joint venture with Trillion Resources Ltd. of Ottawa, Ontario, and the Société d'État pour le Développement Minier de la Côte d'Ivoire.[35]

New Caledonia.—In May 1994, Société Métallurgique Le Nickel (SLN) commissioned its new Kopeto 2 Mine near Nepoui.[36] The open pit mine is about 250 km northwest of the capital of Nouméa. The mine was expected to produce 830,000 mt of lateritic ore annually over the next 15 years and was designed to provide one-third of the feed material required by the company's Doniambo smelter in Nouméa. The garnierite-rich saprolitic ore assays about 2.1% Ni.

The Kopeto 2 Mine is 20 km inland from the coast, at an altitude of about 1,000 m. The area was worked during the 1970's and eventually abandoned. SLN decided to resume mining at the site when 14 untouched ore bodies of garnierite [$(Mg>>Fe, Ni)_3Si_2O_5(OH)_4$] were discovered.

SLN has 10 50-mt dump trucks on-site that haul the garnierite-rich ore to a screening facility. After screening, the ore is slurried and piped 7 km down into the valley to a washing plant and transfer point. Private contractors then truck the washed ore to a storage and reclaiming yard on the coast for transhipment by coastal vessel to Doniambo.

At Doniambo, the ore is blended, partially dried, calcined, and then smelted in one of three electric arc furnaces. The Doniambo smelter produces both ferronickel and a nickel matte. The refined ferronickel averages 29% Ni. The nickel content of the matte is much higher and typically runs about 75% Ni. The matte is cast into ingots and shipped to ERAMET-SLN's Sandouville refinery in northern France for conversion into cathode. In 1994, the Doniambo smelter produced 39,488 mt of Ni in ferronickel and 10,641 mt of Ni in matte.[37]

The opening of the Kopeto 2 Mine created

225 new jobs in a part of the island where unemployment has traditionally run high, and a strong pro-independence movement exists. A 3-year training program was begun in 1993 for the new employees, with $1.33 million provided by SLN and $1.42 million by different agencies of the Province, the French Territory, and the European Community. An additional 50 workers truck ore from the washing plant to the coast or provide other support services on a contract basis.

Norway.—Falconbridge Nikkelverk A/S produced 68,000 mt of refined nickel, up 20% from 56,800 mt in 1993.[38] The 68,000 mt figure broke the company's previous production record of 58,700 mt set in 1991. The refinery was recently upgraded and was operating close to its new capacity of 69,000 mt/a. Nikkelverk employees have developed a unique machine for stripping each sheet of electrodeposited nickel off of its starter sheet. The new machine, a first for the nickel industry, was installed in 1994 and should further increase productivity.

Russia.—RAO Norilsk Nickel produced 162,500 mt of nickel metal in 1994, along with 300,000 mt of copper metal, 3,600 mt of cobalt metal, and 1,200 mt of cobalt oxide.[39] An additional 10,000 to 16,000 mt of nickel was contained in 24,000 mt of matte shipped to Falconbridge's Nikkelverk refinery in Norway.

The Norilsk Nickel operations were partially privatized in April 1994. The new organization is composed of six, largely independent joint-stock companies: Norilsk Complex, Pechenganickel Complex, Severonickel Complex, Krasnoyarsk Nonferrous Metals, Gipronickel Institute, and Olenegorsk Mechanical Works. The Norilsk complex had two new underground mines under development in 1994—the Skalisty and the Gluboky.[40] These would supplement the one large open pit and five underground mines that the complex has had in operation for some time. The Norilsk complex is located on the Taimyr Peninsula of north-central Siberia and has its own nickel smelter plus a matte separation plant, a nickel refinery, and a copper refinery.

Pechenganickel had four mines in operation along the border with Norway. Two of the mines, the Tsentralny and Zapadny, are open pits in the Zhdanovskoye deposit. The other two, the Kaula-Kostalvaara and the Severny, are underground operations. All of the concentrates and direct-shipping ore were going to the smelter at Pechenga for processing along with material from Norilsk. Pechenga produced 86,500 mt of converter matte in 1994, containing 38,600 mt of Ni and 23,400 mt of Cu.

The Severonickel complex at Monchegorsk was processing converter matte from Norilsk and Pechenga, as well as ore from Norilsk. Up until 1977, Severonickel also used local ores as feed, but those reserves are now depleted. Severonickel recently began processing limited amounts of nickel-bearing concentrates, scrap, and residues shipped from abroad.

In November 1994, OMR and two Russian partners formed a joint venture to explore for nickel and other base metals on the Kola Peninsula.[41] The new venture, AOZT Kola Mining, also may help the regional government evaluate and develop several previously identified base metal sulfide deposits. The venture is headquartered in Monchegorsk, the principal townsite for Severonickel. Ownership of Kola Mining is shared between OMR (83%), the State Property Fund for the Murmansk Region (15%), and the Central Kola Expedition, a local geological exploration enterprise (2%).

In a related action, the Murmansk regional government solicited bids from Western companies to develop the Lovno Lake nickel sulfide deposit, about 40 km from the Finnish border. The deadline for bid submission was January 1, 1995. The award was to have been made by March 15. Kola Mining was a bidder and was planning to have a feasibility study completed by late 1996 if it won the competition. Officials of Kola Mining estimated that development of Lovno Lake would cost $150 million to $180 million. The Lovno ores are relatively low in nickel and copper (0.88% Ni and 0.43% Cu) compared with those at Norilsk, but contain above average concentrations of cobalt. Preliminary studies indicated that the Lovno deposit has about 8 to 10 million mt of ore, or roughly 12 years of reserves. The mine would initially be an open pit operation. Mining would move underground after 5 to 6 years to exploit the deeper ores.

OMR was also participating in a joint venture in neighboring Karelia. The venture, A/O Kivijärvi, was set up in 1992 to explore for copper and nickel and conduct mine feasibility studies of deposits in the Kivijärvi area, northeast of Aanisjärvi. This second venture is headquartered in Petrozavodsk and also operates from Segezha, on the Belomorsk Canal.[42]

South Africa.—The Columbus Stainless Steel Project was more than 97% complete and was scheduled to be commissioned in the fall of 1995. The huge stainless steelmaking complex had been under construction in the Transvaal since December 1992. When fully operational, the complex will be the largest single site producer of stainless and related chromium-bearing steels in the world.

The project is a joint venture of Samancor Ltd., Highveld Steel and Vanadium Ltd., and the Industrial Development Corp., each holding a one-third share. The project is costing the partnership 3.5 billion Rand *(roughly US$1 billion).*

The new mill was being built around the existing Southern Cross stainless steel plant at Middelburg. Southern Cross Steel Co. (Pty.) Ltd. was the first company in South Africa to produce stainless steel, inaugurating operations at Middelburg in 1967. The company was acquired later by Middelburg Steel & Alloys (Pty.) Ltd., a wholly owned subsidiary of the Barlow Rand Group, only to be sold in July 1991 to the Columbus Joint Venture (i.e., the Columbus partnership).

The existing Southern Cross melt shop has a 50-mt electric arc furnace (EAF), a 60-mt argon-oxygen decarburization (AOD) furnace, and a single strand slab caster that together can produce up to 125,000 mt/a of crude stainless. This facility was being replaced by a totally new melt shop, which abuts the new combined hot rolling mill and cold rolling mill complex.

When the expansion is completed, the new melt shop will be able to produce 450,000 to 600,000 mt of continuous cast slab. Molten ferrochromium was being taken directly from Samancor's adjoining ferroalloy plant to the melt shop. There, the molten ferrochromium can be charged to either the EAF or the converter. The stainless steel was being refined using the Creusot-Loire-Uddeholm (CLU) process developed in the early 1970's. In the CLU process, superheated steam is used along with the oxygen as a refining agent.[43]

The production target for 1995 was 250,000 mt of stainless. Full production of 600,000 mt was scheduled to be reached in 1997. Products would include hot-rolled coil and band, cold-rolled band, cold-rolled plate of varying sizes, and slab.[44]

Impala Platinum Holdings Ltd. and Rustenburg Platinum Holdings Ltd. have been supplying most of the primary nickel consumed by the Columbus Joint Venture. South Africa produces about 30,000 mt/a of nickel as a byproduct of its platinum mines. However, by 1997, Columbus will require at least 48,000 mt/a of nickel. At that point, the joint venture plans to buy nickel on the world market. Only one-half of its nickel requirements would come from local sources. South Africa may have to import even more nickel if Iscor Ltd. proceeds with its plan to convert part of its Pretoria Works to stainless production.[45]

In September 1994, Gencor and the Royal Dutch/Shell Group finalized the terms on the sale of Billiton BV to Gencor. Gencor reportedly paid Shell $1.14 billion for the international mining, metals smelting, and trading company. Gencor is one of the larger mining houses in South Africa, with roots dating back to 1895. The long-awaited transfer of assets transformed Gencor into an international resource group. Gencor's new subsidiary is called Billiton International Ltd. The South African mining company had to put up $335 million in cash. The bulk of the remaining $809 million was loaned to Gencor by a consortium of international banks.

Gencor has become increasingly involved with nickel in recent years. The company is a majority stockholder in Samancor, giving it a direct interest in both South African ferroalloy production and the Columbus project. Gencor has a 42% interest in Impala Platinum which can produce roughly 12,000 mt/a of refined nickel as byproduct of its platinum operations in Bophuthatswana.

Gencor and the giant Anglo American Corp. of South Africa Ltd. have a number of mutual interests. Anglo American also is involved in the Columbus project through its holdings in Highveld. Like Gencor, Anglo American has sizable investments in South African companies that produce nickel as a byproduct of platinum mining. Another Anglo American subsidiary, Kaffrarian Metal Holdings (Pty.) Ltd., is a partner with Anglovaal Ltd. in the Nkomati (River of Cows) nickel-cobalt-copper exploration program.

Anglo American and Anglovaal have joined forces to explore a sill-like layered ultramafic complex in the eastern part of the Transvaal. To date, work has focused on the Slaaihoek farm and the adjoining Uitkomst farm where several zones of sulfide mineralization have been identified.[46]

Tanzania.—Additional nickel-copper-cobalt resources have been identified at Kabanga on the Burundi border. The Kabanga deposit was discovered by geologists with the United Nations Development Program in 1979 and acquired by Sutton Resources Ltd. in 1990. Since then, infill drilling by Sutton has confirmed the existence of a zone of moderately high nickel sulfide mineralization—the Main Zone. The Kabanga deposit is now being thoroughly evaluated as part of a joint venture between Sutton and BHP Minerals International Exploration Inc. (BHP Minerals). BHP Minerals has had drill rigs operating in the area since 1993.

In late 1993, stepout drilling intersected nickel sulfides about 1,100 m north of the Kabanga Main Zone. Subsequent infill drilling about 700 m north of the Main Zone has revealed a second, somewhat richer zone of nickel mineralization of unknown extent. According to Sutton consultants, this latest discovery - the North Zone - has at least 12.4 million mt of sulfide ore grading 2% Ni, 0.27% Cu, and 0.19% Co.[47] In comparison, the Main Zone has 23.1 million mt of ore averaging 1.19% Ni, 0.20% Cu, and 0.10% Co, based on a 0.5% Ni cutoff.

The Kabanga project is tied to a larger, ongoing exploration program that covers the entire Kagera region from Kabanga to the Uganda border. The region is bordered on the west by Rwanda and on the east by Lake Victoria. BHP is paying all of the exploration costs under an equity earning agreement reached with Sutton in June 1992. That same year, the Government of Tanzania awarded Sutton's Tanzanian subsidiary sole exploration rights in the Kagera Concession in exchange for a 10% position in the Kagera venture and a 3% royalty on any minerals produced. The Government also has a similar 10% position in the Kabanga venture.[48]

Current Research and Technology

Recent developments in Ni-Cd battery technology were reviewed at an international conference on September 19-20, 1994, in Geneva, Switzerland. The conference—*NiCad94*—was organized by the International Cadmium Association with the cooperation and support of Eurobat. Four of the 27 papers presented discussed large-scale field testing of EV's in Europe. Another eight dealt with the collection and recycling of spent batteries in both Europe and North America.

The Ni-Cd, nickel-metal hydride (Ni-MH), lithium-ion, and improved lead-acid electrochemical systems are in strong competition with one another for the portable rechargeable battery market. Improvements are continually being made to each of the systems. Energy density, cycle life, charge retention, shelf life, and performance at extreme temperatures are all being enhanced. These enhancements are being carried over into the emerging electric vehicle battery market—a market some analysts believe will be worth $300 million by the year 2000.

France, Germany, Japan, and the United States continue to be the principal manufacturers and users of Ni-Cd and Ni-MH batteries. However, tremendous strides have been made by competitors in China and Hong Kong since 1990. China now has nine Ni-Cd battery manufacturing operations. Another five Chinese suppliers produce Ni-Cd batteries as a sideline of their zinc-manganese dry cell operations. Seven of the fourteen Ni-Cd suppliers also manufacture Ni-MH batteries. An eighth, Innotec Environmental Energy Co. Ltd. in Tianjin, makes nothing but Ni-MH batteries.[49]

In France, the La Rochelle electric vehicle experiment is now in its sixth year of testing. The tests are a joint project of the city of La Rochelle, the automobile manufacturer PSA Peugeot Citroën, and the electric utility Electricité de France (EDF). Fifty EV's are currently operating in the city. Forty-six of the 50 EV's are powered by Ni-Cd systems; four by lead-acid.[50]

German automobile manufacturers have been conducting similar field tests in Zurich, Switzerland, and on the island of Rügen in the Baltic Sea. The 4-year project began in 1992 and is being run by Deutsche Automobilgesellschaft mbH (DAUG) with the support of the German Federal Ministry for Research and Technology. Of the 59 vehicles being tested, 23 have sealed Ni-Cd batteries developed by DAUG. Another 31 of the Rügen vehicles are being powered by sodium metal-nickel chloride (Na°-$NiCl_2$) batteries made by AEG AG.[51]

The DAUG battery minimizes gas pressures within the cell by using split negative, cadmium electrodes. Because of the unique electrode design, oxygen evolution is automatically controlled. The near-zero gas pressure allows the battery to be sealed and made maintenance-free. DAUG and Accumulatorenwerke HOPPECKE have formed a joint venture to manufacture the advanced Ni-Cd battery.

In the United States, commercial production of EV's powered by nickel batteries moved one step closer to reality. On May 13, 1994, the California Air Resources Board (ARB) reaffirmed its requirement that, beginning with the 1998 model year, 2% of all vehicles sold within the State must have zero tailpipe emissions. The regulation, adopted in 1990, requires all automobile manufacturers who sell more than 35,000 cars or light trucks annually in California after 1997 to certify that at least 2% of total sales were zero emission vehicles (ZEV's). The sales requirement jumps to 5% in the year 2001, and then to 10% in 2003. At the present time, only EV's can satisfy the zero emission requirement.[52]

Several auto manufacturers had hoped that the ARB would delay the deadline, giving the companies more time to improve the performance of their prototype EV's. The auto manufacturers were concerned about the limitations of existing battery technology (range, speed, manufacturing cost, and so forth) and the absence of a network of recharging stations. The Board, however, concerned about increasingly severe air quality problems in the Los Angeles basin, rejected the auto manufacturers' arguments. The Board then went on to adopt a detailed report prepared by its staff which concludes that zero-emission vehicles are "technologically feasible in the timeframe provided."[53]

The reaffirmation is important to nickel producers as well as battery manufacturers. During the near-term (1995-2000), at least four nickel-based EV batteries are expected to strongly compete with the new high-performance lead-acid battery being developed in Texas and other lead-based batteries of advanced design. The four nickel-based technologies are: nickel-cadmium, nickel-iron, nickel-metal hydride, and sodium metal-nickel chloride. In 1993, Chrysler Corp. demonstrated electric vehicle technology by driving a Ni-Cd powered, seven passenger minivan 2,500 miles from Detroit to Los Angeles in about 160 hours.

For several years now, the Ovonic Battery Co. has been developing an advanced Ni-MH battery for EV's. Part of this work is being funded by the U.S. Advanced Battery Consortium (USABC) under a long contract worth $19.9 million. The USABC recently awarded the Michigan company an additional $5.5 million to improve the performance of its existing Ni-MH EV battery while simultaneously lowering production costs.

In June 1994, General Motors Corp. (GM) entered into a joint venture with OBC to manufacture EV batteries utilizing proprietary Ni-MH technology. Details of the agreement were not disclosed. GM reportedly plans to begin pilot production of the Ovonic Ni-MH battery in 1996. The California Air Resources Board has been testing a number of EV's, including a four-seater Solectria powered by Ovonic Ni-MH batteries. Preliminary results indicate that the Solectria has a range of 275 km (170 miles) at approximately 80 km per hour (50 miles per hour).[54] Solectria Inc. turns motorless versions of the Geo Metro and other "gliders" into EV's at its plant in Wilmington, MA.

Outlook

Demand for austenitic stainless steel will continue to drive the world nickel market for at least another 20 years. World consumption of stainless steel is expected to grow between 3% and 9% annually from 1996 to the year 2000. This growth rate should increase substantially at some point when the Russian economy inevitably turns around and a rejuvenated Russian industry begins consuming the large amounts of stainless sheet and plate required by a technologically advanced, market-oriented society.

Demand for austenitic stainless has already resumed its upward growth in several OECD countries recovering from the global recession of 1991-93. Stainless production capacity is being expanded in some of the newly industrialized countries of the Far East that successfully weathered the recession. Brazil and South Africa both are poised to be major producers of stainless steel.

Many of the demand problems that hurt nickel producers in 1993 have receded. Western producers have largely adjusted to the massive Russian exports of cathode. Supplies of stainless scrap have tightened, and the nickel industry is again expanding mining and smelting capacity on a global basis. New technologies are being explored for improving the economics of recovering nickel from laterites.

The development of the Voisey Bay deposit should ease the fears of many consumers about future shortages of nickel. Recent drilling has delineated additional resources at depth in the immediate area of the discovery site and changed long-range thinking about future exploration targets elsewhere in the Northern Hemisphere. More than 100 companies currently are doing field work in the Voisey Bay region. Three of the more promising areas include Harp Lake, Niatak Island, and Tasisuak Lake.

Although still relatively small, demand for nickel in rechargeable batteries is growing at more than 10% per year. Manufacturing of Ni-Cd and Ni-MH batteries is expected to increase significantly over the next 5 years even if both chemistries are rejected for EV's. Nickel-based batteries will continue to be used in rechargeable power tools, home appliances, and other household equipment because of cost constraints. The markets for battery-powered cellular telephones, laptop computers, and other portable electronic equipment are exploding. Many of the newest satellites and commercial aircraft are using advanced Ni-Cd's for their secondary power sources.

A nationwide recycling system for nickel-based batteries is being set up in the United States that should lessen environmental concerns. INMETCO now has on-site facilities for refining the recovered cadmium and converting it into marketable stick. This was the last major technical impediment to unrestrained recycling of household and industrial Ni-Cd's.

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TABLE 1
SALIENT NICKEL STATISTICS 1/

(Metric tons of contained nickel unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Mine production	330	5,520	6,670	2,460	--
Plant production	3,700	7,070	8,960	4,880	--
Secondary recovery from purchased scrap:					
From ferrous scrap	48,600	44,800	47,700	46,600 r/	48,900
From nonferrous scrap	8,760	8,700	8,140	7,460	9,690
Exports:					
Primary	8,870	9,100	8,560	7,180	7,440
Secondary	28,200	27,800	25,300	26,000	34,500
Imports for consumption:					
Ore	--	371	3,580	2,970	--
Primary	134,000	132,000	119,000	126,000	127,000
Secondary	11,600	6,210	9,510	6,710	6,060
Consumption:					
Reported:					
Primary	121,000	109,000	101,000	105,000 r/	107,000
Secondary (purchased scrap)	57,400	53,500	55,900	54,000 r/	58,600
Total	178,000	162,000	157,000	159,000 r/	166,000
Apparent:					
Primary	127,000	125,000	119,000	122,000 r/	134,000
Secondary (purchased scrap)	42,800	31,400	40,300	36,600 r/	30,500
Total	170,000	157,000	159,000	158,000 r/	164,000
Stocks, yearend:					
Government	33,800	33,800	33,800	31,600	26,800
Producer and traders	8,070	11,800	10,100	15,700 r/	10,200
Consumer:					
Primary	9,060	10,500 r/	12,300 r/	11,100 r/	7,210
Secondary	4,920	5,440	5,180	3,330 r/	2,990
Employment, yearend:					
Mine	12	8	10	2	1
Smelter	300	277	250	33	22
Port facility	--	--	23	5	3
Price, cash, London Metal Exchange:					
Per metric ton	$8,864	$8,156	$7,001	$5,293	$6,340
Per pound	$4.021	$3.699	$3.176	$2.401	$2.876
World: Mine production	974,000 r/	991,000 r/	981,000 r/	905,000 r/	895,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices; may not add to totals shown.

TABLE 2
NICKEL RECOVERED FROM PURCHASED SCRAP IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY 1/

(Metric tons of contained nickel)

	1993	1994
KIND OF SCRAP		
Aluminum-base 2/	2,350	3,150
Copper-base	2,060	2,970
Ferrous-base 3/	46,600 r/	48,900
Nickel-base	3,040	3,570
Total	54,000 r/	58,600
FORM OF RECOVERY		
Aluminum-base alloys 4/	2,350	3,150
Copper-base alloys	3,680	4,830
Ferrous alloys	46,600 r/	48,900
Nickel-base alloys	1,370	1,620
Miscellaneous and unspecified	2	41
Total	54,000 r/	58,600

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Primarily used beverage cans and foundry borings and turnings.

3/ Primarily stainless and alloy steel scrap consumed at steel mills and foundries.

4/ Includes can scrap converted to ingot by toll smelters for sale on open market.

TABLE 3
REPORTED U.S. CONSUMPTION OF NICKEL, BY FORM 1/

(Metric tons of contained nickel)

Form	1993	1994
Primary:		
Metal	72,000 r/	80,100
Ferronickel	21,300 r/	18,900
Oxide and oxide sinter 2/	4,440	3,690
Chemicals	1,800 r/	1,730
Other	5,700	3,000
Total primary	105,000	107,000
Secondary (scrap) 3/	54,000 r/	58,600
Grand total	159,000 r/	166,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Included chemical-grade oxide.

3/ Based on gross weight of purchased scrap consumed and estimated average nickel content.

TABLE 4
U.S. CONSUMPTION OF NICKEL IN 1994, BY USE 1/

(Metric tons of contained nickel)

Use	Metal	Ferro-nickel	Oxide and oxide sinter	Chemicals	Other forms	Total primary	Secondary (scrap)	1994 grand total	1993 grand total
Cast irons	227	W	(2/)	W	47	274	225	499	805 r/
Chemicals and chemical uses	1,250	--	W	1,420	W	2,670	--	2,670	1,170 r/
Electric, magnet, expansion alloys	W	W	--	--	--	W	W	W	W
Electroplating (sales to platers)	15,500	(2/)	W	W	10	15,500	W	15,500	16,600 r/
Nickel-copper and copper-nickel alloys	3,750	W	W	W	W	3,750	4,190	7,940	6,080
Other nickel and nickel alloys	19,100	W	W	--	W	19,100	1,430	20,500	17,000
Steel:									
Stainless and heat-resistant	18,500	17,600	2,720	--	2,340	41,200	47,500	88,700	87,300 r/
Alloys (excludes stainless)	4,790	W	W	--	(2/)	4,790	1,140	5,930	4,940 r/
Superalloys	11,700	--	(2/)	W	W	11,700	W	11,700	10,800
Other 3/	5,160	1,290	973	303	595	8,320	4,070	12,400	14,500 r/
Total reported	80,100	18,900	3,690	1,730	3,000	107,000	58,600	166,000	159,000 r/
Total all companies, apparent	XX	XX	XX	XX	XX	134,000	30,500	164,000	158,000 r/

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Includes batteries, catalysts, ceramics, coinage, and other alloys containing nickel, and data represented by symbol "W."

TABLE 5
NICKEL IN CONSUMER STOCKS IN THE UNITED STATES, BY FORM 1/

(Metric tons of contained nickel)

Form	1993	1994
Primary:		
Metal	8,010 r/	4,880
Ferronickel	1,710 r/	553
Oxide and oxide sinter	915	1,230
Chemicals	281 r/	287
Other	158	263
Total primary	11,100 r/	7,210
Secondary (scrap)	3,330 r/	2,990
Grand total	14,400 r/	10,200

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 6
U.S. EXPORTS OF NICKEL PRODUCTS, BY CLASS 1/

(Metric tons of contained nickel unless otherwise specified)

Class	1993		1994	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Unwrought primary:				
Cathodes, pellets, briquets, and shot	755	$4,130	564	$4,040
Ferronickel	669	2,310	35	96
Powder and flakes	573	8,090	1,090	10,000
Metallurgical-grade oxide 2/	3,750	6,550	3,640	7,370
Chemicals: 3/				
Catalysts	987	52,400	1,630	60,400
Salts	450	6,640	480	7,430
Total	7,180	80,100	7,440	89,300
Unwrought secondary: 4/				
Stainless steel scrap	17,900	147,000	22,400	190,000
Waste and scrap	8,170	31,700	12,100	45,200
Total	26,000	179,000	34,500	235,000
Grand total	33,200	259,000	41,900	325,000
Wrought:				
Bars, rods, profiles and wire	237	2,010	257	3,280
Sheets, strip and foil	215	2,260	121	2,060
Tubes and pipes	99	1,490	49	573
Total	551	5,760	427	5,920
Alloyed (gross weight):				
Unwrought alloyed ingot	1,890	18,600	2,830	21,000
Bars, rods, profiles and wire	4,540	63,600	4,290	59,600
Sheets, strip and foil	5,700	74,300	6,180	86,500
Tubes and pipes	1,060	24,900	1,160	22,300
Other alloyed articles	1,750	51,000	2,580	36,400
Total	14,900	232,000	17,000	226,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Chemical-grade oxide is included with the "Salts" category.

3/ For the different salts, the nickel contents are assumed to be as follows: chlorides, 25%; sulfates, 22%; other salts, 22%; and oxide, sesquoxide and hydroxide, 65%. The typical catalyst is assumed to have a nickel content of 22%.

4/ The nickel content of waste and scrap is assumed to be 50%, while that of stainless steel has been shown to be about 7.5%.

Sources: Bureau of the Census and Journal of Commerce.

TABLE 7

U.S. EXPORTS OF NICKEL PRODUCTS IN 1994, BY COUNTRY 1/

(Metric tons of contained nickel 2/)

Country	Cathodes, pellets, and briquets, (unwrought)	Powder and flakes	Ferro-nickel	Metal-lurgical grade oxide 3/	Waste and scrap	Stainless steel scrap	Chemicals	Totals 1994	Totals 1993	Wrought nickel 4/
Australia	–	2	–	104	78	–	9	193	88	1
Belgium	–	116	–	–	17	721	88	942	967	1
Canada	218	562	1	3,260	7,720	3,680	325	15,800	12,700	46
China	–	–	–	–	86	170	14	270	391	3
Colombia	9	2	–	43	–	–	13	67	19	44
Finland	–	–	–	–	85	–	–	85	640	(5/)
France	46	7	–	–	62	20	34	169	188	71
Germany	–	10	–	20	551	69	50	700	493	1
India	–	(5/)	–	–	28	357	2	387	394	1
Italy	–	(5/)	–	(5/)	22	1	2	25	40	–
Japan	–	36	–	111	1,230	1,900	476	3,750	4,650	5
Korea, Republic of	62	94	–	3	112	5,760	124	6,150	5,310	17
Mexico	203	74	1	(5/)	11	27	186	502	526	56
Netherlands	–	4	–	(5/)	449	982	31	1,470	1,110	8
Russia	–	–	–	–	9	–	–	9	129	–
Spain	–	(5/)	–	1	164	5,320	3	5,490	3,090	–
Sweden	–	2	–	(5/)	971	1,680	1	2,650	220	(5/)
Taiwan	–	6	33	(5/)	66	565	31	701	779	15
United Kingdom	1	45	–	7	407	396	19	875	471	46
Other	25	126	–	99	10	760	702	1,720	986	112
Total	564	1,090	35	3,640	12,100	22,400	2,110	41,900	33,200	427

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The nickel contents are assumed to be as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The chemical category contains the following: chemical-grade oxide, sesquoxide, and hydroxide, 65%; chlorides, 25%; and sulfates, 22%; other salts and various catalysts are assumed to be 22% nickel.

3/ Chemical-grade oxide is included with salts and catalysts in the chemicals category.

4/ Not included in "Total."

5/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS , BY CLASS 1/

(Metric tons of contained nickel 2/ unless otherwise specified)

Class	1993		1994	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Unwrought primary:				
Cathodes, pellets, briquets, and shot	95,900	$516,000	95,700	$552,000
Ferronickel	13,200	66,500	15,300	85,500
Flakes	212	1,320	275	2,020
Powder	8,490	73,700	8,800	78,400
Metallurgical-grade oxide	4,490	25,300	3,070	18,700
Chemicals:				
Catalysts	2,490	41,900	2,330	36,700
Salts	1,540	15,000	1,620	16,700
Total	126,000	739,000	127,000	790,000
Unwrought secondary:				
Stainless steel scrap	3,700	20,200	3,190	20,200
Waste and scrap	3,020	19,100	2,880	21,700
Total	6,710	39,300	6,060	41,900
Grand total	133,000	779,000	133,000	832,000
Wrought:				
Bars, rods, profiles and wire	449	4,920	238	3,100
Sheets, strip and foil	490	9,480	352	4,440
Tubes and pipes	52	1,040	45	1,200
Total	991	15,400	634	8,740
Alloyed (gross weight):				
Unwrought alloyed ingot	2,720	19,500	2,720	20,300
Bars, rods, profiles and wire	2,170	24,200	2,470	28,000
Sheets, strip and foil	1,280	16,000	1,310	15,300
Tubes and pipes	570	15,600	801	19,900
Other alloyed articles	306	5,450	380	10,200
Total	7,050	80,800	7,680	93,800

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The nickel contents are as follows: metallurigical-grade oxide from Australia 90%; elsewhere 77%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides , 25%; sulfates, 22%;, and other salts which are assumed to be 22% nickel. The typical catalyst is assumed to have a nickel content of 22%. Waste and scrap is assumed to be 50% nickel; stainless steel scrap, 7.5% nickel.

Sources: Bureau of the Census and Journal of Commerce.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY 1/

(Metric tons of contained nickel 2/)

Country	Cathodes, pellets, and briquets, (unwrought)	Powder and flakes	Ferro-nickel	Metal-lurgical grade oxide 3/	Waste and scrap	Stainless steel scrap	Chemicals	Totals 1994	Totals 1993	Wrought nickel 4/
Australia	13,400	1,170	--	2,730	18	--	--	17,300	13,600	--
Austria	--	40	119	--	--	--	(5/)	159	381	(5/)
Belgium	--	--	--	--	7	--	282	289	600	(5/)
Brazil	4,760	--	380	--	--	--	4	5,150	2,240	--
Canada	38,000	6,700	--	336	1,000	1,770	1,810	49,600	62,300	53
Colombia	--	--	2,120	--	4	10	--	2,130	1,210	--
Dominican Republic	--	--	8,140	--	27	--	--	8,170	6,280	--
Finland	2,090	--	--	--	--	--	423	2,520	2,450	--
France	1,100	(5/)	--	--	479	--	192	1,770	2,010	47
Germany	20	9	--	--	293	--	253	575	503	453
Japan	1	3	5	(5/)	69	16	560	654	740	15
Macedonia	--	--	--	--	--	--	--	--	295	--
Mexico	--	--	--	--	33	1,060	(5/)	1,090	1,460	--
New Caledonia	--	--	3,760	--	--	--	--	3,760	4,080	--
Norway	22,300	2	--	--	17	--	--	22,300	18,500	--
Russia	4,660	640	790	--	15	2	27	6,130	6,720	--
South Africa, Republic of	4,830	352	25	--	3	--	48	5,260	5,580	--
United Kingdom	880	107	4	--	659	--	51	1,700	823	10
Zimbabwe	2,640	--	--	--	--	--	--	2,640	1,950	--
Other	1,010	47	9	--	248	329	295	1,950	1,360	56
Total	95,700	9,070	15,300	3,070	2,880	3,190	3,940	133,000	133,000	634

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The nickel content of metallurgical-grade oxide from Australia is assumed to be 90%; elsewhere 77%. The chemicals category contains the following: chemical-grade oxide, sequoxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts, which are assumed to be 22% nickel. The typical catalyst is assumed to have a nickel content of 22%.

3/ Primarily oxide rondelles and sinter.

4/ Not included in "Total."

5/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of nickel content)

Country	1990	1991	1992	1993	1994 e/
Albania (content of ore) e/	8,800	7,500	150	75	--
Australia (content of concentrate)	67,000	69,000	57,700	64,700	71,900
Botswana (content of ore milled)	23,200	23,500	23,000	23,000	23,000
Brazil (content of ore)	24,100 r/	26,400 r/	29,400 r/	32,200 r/	32,000
Burma (content of ore) e/	42 r/	15 r/	9 r/	67 r/	50
Canada (content of concentrate)	196,000	192,000	186,000	188,000	150,000 3/
China e/	33,000	30,400	32,800	30,700 r/	33,000
Colombia (content of laterite ore)	22,400	20,600	23,100	23,300	23,500
Cuba (content of oxide, sinter, sulfide) e/	40,800	33,300	32,200	30,200	26,000
Dominican Republic (content of ferronickel produced)	28,700	29,100	27,500	23,900	30,500
Finland (content of concentrate)	11,500	9,900	9,870	8,290 r/	7,250 3/
Germany	872	XX	XX	XX	XX
Greece (laterite ore)	18,500	19,300	17,000 r/	12,900 r/	19,000
Indonesia (content of ore)	68,300	71,700	77,600	65,800 e/	81,100 3/
New Caledonia (content of ore)	85,100	114,000	113,000	97,100 r/	96,000 3/
Norway (content of concentrate)	3,100	2,200	3,400	3,460	3,320 3/
Philippines	15,800	13,700	13,000 r/	7,660 r/	9,800
Russia e/	XX	XX	280,000	243,000	240,000
Serbia and Montenegro (content of ferronickel produced) 4/	XX	XX	1,860 r/	443 r/	450
South Africa, Republic of (content of concentrate)	29,000	27,700	28,400	30,000 r/ e/	31,000
Ukraine e/	XX	XX	5,900 r/	4,500	4,000
U.S.S.R. (content of ore) e/ 5/	280,000	280,000	XX	XX	XX
United States (content of ore shipped)	330	5,520	6,670	2,460	--
Yugoslavia (content of ferronickel produced) e/ 4/ 6/	3,600	2,400	XX	XX	XX
Zimbabwe (content of concentrate)	13,500	12,400	12,400	12,800	13,500 3/
Total	974,000 r/	991,000 r/	981,000 r/	905,000 r/	895,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Insofar as possible, this table represents recoverable mine production of nickel. Where actual mine output is not available, data related to a more highly processed form have been used to provide an indication of the magnitude of mine output and this is noted parenthetically or by a footnote following the country name. Five members of the European Union, the Republic of South Korea, and the United States reported receiving ferronickel originating from Macedonia, but definitive information on the output of the Kavadarci operation was not available.

3/ Reported figure.

4/ All production in Yugoslavia for 1990-91 came from Serbia and Montenegro.

5/ Dissolved in Dec. 1991.

6/ Dissolved in Apr. 1992.

TABLE 11
NICKEL: WORLD PLANT PRODUCTION BY COUNTRY AND PRODUCT 1/ 2/

(Metric tons of nickel content)

Country 3/ and product	1990	1991	1992	1993	1994 e/
Albania: Metal e/	2,500	2,200	50	50	50
Australia: Unspecified	43,100 r/	49,400 r/	50,600 r/	50,400 r/	45,900 4/
Austria: Ferronickel	3,300	3,500	3,900 r/	3,200 r/	2,100
Brazil: 5/					
Ferronickel	8,850	8,620	8,740 r/	8,680 r/	8,700
Metal	4,160	5,220	5,930	7,020 r/	7,000
Total	13,000	13,800	14,700 r/	15,700 r/	15,700
Canada: Unspecified 6/	135,000	132,000	135,000	123,000	105,000 4/
China: Metal e/	27,500	28,900	30,800	30,500 r/	31,000
Colombia: Ferronickel	18,400	20,200	20,200	18,000 r/	20,800 4/
Cuba: Oxide 7/	21,100	18,800	16,900	16,200 r/	14,100 4/
Czechoslovakia: Metal 8/ 9/	2,970 e/	2,400 e/	1,620	XX	XX
Dominican Republic: Ferronickel	28,700	29,100	27,500	23,900	30,500
Finland:					
Chemicals	1,640	2,160	2,890	3,130	4,190
Metal	16,900	13,900	14,800	14,800	15,900
Total	18,500	16,000	17,700	17,900	20,100
France:					
Chemicals	1,090	1,000	1,200 e/	1,200 e/	1,200
Metal	8,540	7,400	6,800 e/	10,400 r/	10,000
Total	9,630	8,400	8,000 e/	11,600 r/ e/	11,200
Germany: Eastern states: Metal	1,660	850	XX	XX	XX
Greece: Ferronickel	15,700	16,000	15,400	10,900 r/	16,200 4/
Indonesia: Ferronickel	5,010	5,320	5,510	5,270	5,800 4/
Japan:					
Ferronickel	56,500	68,000	57,400	51,100 r/	58,200
Metal	22,300	23,700	22,000	22,600 r/	25,300 4/
Oxide	21,500	22,500	27,500	27,000 r/	27,000
Total	100,000	114,000	107,000	101,000 r/	111,000
Korea, Republic of: Metal e/	5,990 4/	11,300	10,000	10,000	10,000
New Caledonia: Ferronickel	32,300	34,400	31,900	36,900	39,500 4/
Norway: Metal	57,800	58,700	55,700	56,800	68,000 4/
Russia: e/ 10/					
Ferronickel	XX	XX	22,000	17,000	15,000
Metal	XX	XX	205,000	160,000	155,000
Oxide	XX	XX	13,000	10,000	8,000
Chemicals	XX	XX	3,000	2,000	2,000
Total	XX	XX	243,000	189,000	180,000
Serbia and Montenegro: Ferronickel	XX	XX	1,860 r/	443 r/	450
South Africa, Republic of: Metal	28,200	26,900	27,600	29,900 r/	30,100 4/
Sweden: Metal	610	490	500 e/	500 e/	500
Taiwan: Metal e/	10,400	11,200	10,000	9,000	10,000
Ukraine: Ferronickel e/	XX	XX	5,000 r/	3,500	3,000
U.S.S.R.: e/ 10/ 11/					
Ferronickel	22,000	20,000	XX	XX	XX
Metal	240,000	230,000	XX	XX	XX
Oxide	13,000	12,000	XX	XX	XX
Total	275,000	262,000	XX	XX	XX
United Kingdom: Metal	26,800	29,000	28,000 e/	28,000 e/	28,000
United States: Ferronickel	3,700	7,070	8,960	4,880	-- 4/
Yugoslavia: Ferronickel e/	3,600	2,500	XX	XX	XX
Zimbabwe: Metal 12/	11,400	11,300	10,300	11,100	11,500
Total chemicals	2,730	3,160	7,090	6,330	7,390
Total ferronickel	198,000	215,000	208,000 r/	184,000 r/	200,000
Total metal	468,000	463,000	429,000	391,000 r/	402,000
Total oxide	55,600	53,300	57,400	53,200 r/	49,100
Total unspecified	178,000	181,000 r/	186,000 r/	174,000 r/	151,000
Grand total	902,000	915,000 r/	888,000 r/	808,000 r/	810,000

See footnotes at end of table.

e/ Estimated. r/ Revised. XX Not applicable.

1/ Table includes data available through July 27, 1995.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ In addition to the countries listed, North Korea is believed to have produced metallic nickel and/or ferronickel, but information is inadequate to make reliable estimates of output levels. Between 1992 and 1994, five members of the European Union, the Republic of South Korea, and the United States reported recieving ferronickel originating from Macedonia, but definitive information on the output of the Kavadarci operation was not available. Several countries produce nickel-containing matte, but output of nickel in such materials has been excluded from this table in order to avoid double counting. Countries producing matte include the following, with output indicated in metric tons of contained nickel: Australia (estimated): 1990-94--45,000; Botswana: 1990--19,000; 1991--19,300; 1992--18,900; 1993--21,600; and 1994--20,600 (estimated); Canada (estimated): 1990--43,300; 1991-94--40,000; Indonesia: 1990--24,900; 1991--27,400; 1992-- 39,300; 1993--37,000 (revised); and 1994--37,000; New Caledonia: 1990--9,680; 1991--9,040; 1992--7,480; 1993--10,900; and 1994--10,600.

4/ Reported figure.

5/ Brazil is believed to also produce nickel oxide, but information is not available on which to base estimates.

6/ Nickel contained in products of smelters and refineries in forms which are ready for use by consumers.

7/ Cuba also produces nickel sulfide but, because it is used as feed material elsewhere, it is not included to avoid double counting. Output of processed sulfide was as follows, in metric tons: 1990--19,700; 1991--14,600; 1992--15,300; 1993--14,000; and 1994--12,800.

8/ Dissolved Dec. 31, 1992.

9/ All production in Czechoslovakia from 1990-92 came from Slovakia. Production for 1993 is estimated to be zero.

10/ Includes production from sulfidized concentrates shipped from Cuba for toll refining.

11/ Dissolved in Dec. 1991.

12/ Excludes production from matte shipped from Botswana for toll refining.

NITROGEN

By Raymond L. Cantrell

In 1994, nitrogen compound supplies in the United States reached an all time record high because of strong domestic demand for agricultural and industrial products; an extremely tight supply situation was experienced. The total value of the U.S. nitrogen compound supply, f.o.b. U.S. Gulf, nearly doubled to an impressive $5.0 billion, compared with $2.7 billion during the previous year.

A unique combination of strong upward movement in the domestic nitrogen market led to several new all time record highs, including nitrogen fertilizer consumption[1] and agricultural exports.[2] Record quantities of imported ammonia were required to meet heavy demand. Ammonium phosphate export shipments to China more than doubled to a record high 5.4 million metric tons, adding substantially to ammonia demand. A strong performance by the industrial sector further contributed to extremely tight supplies and upward price pressure. Profitability was enhanced by reasonably priced natural gas feedstock for ammonia production,[3] industry consolidation, and a favorable balance between supply and demand in the global fertilizer and grain sectors.[4]

Legislation and Government Programs

The President signed the Uruguay Round GATT Agreements Act, H.R. 5110—Public Law No. 103-465—on December 8, 1994. The new multilateral General Agreement on Tariffs and Trade was expected to gradually result in the lowering of global tariff barriers, thus improving the prospects for improved access of U.S. agricultural exports to major countries around the globe.[5]

Section 313 of the Environmental Protection Agency's (EPA) Emergency Planning and Community Right-to-Know Act of 1986 (Public Law 99-499) required EPA to establish a national inventory of toxic chemical emissions from certain facilitates, called the Toxics Release Inventory (TRI). EPA's 1992 TRI published in April 1994, revealed that ammonia ranked first in terms of total releases, and second in terms of direct releases to the air, water, and land. Ammonia ranked first in terms of underground injection, second in discharges to surface water, and third in terms of the largest emissions to the air. Ammonium nitrate solution, nitric acid, acetonitrile, and ammonium sulfate solution were also listed in the top 50 TRI releases, in order of importance.[6]

Production

U.S. ammonia producers operated at more than 100% of design capacity in 1994. Ammonia ranked as the sixth largest volume chemical produced in the United States, according to information published by Chemical and Engineering News in April 1995. Approximately 87% of domestic production was for fertilizers, and 13% for industrial use. Urea, ammonium nitrate, ammonium phosphates, ammonium sulfate, and nitric acid for direct use, were the major downstream products produced from ammonia in the United States, in order of importance.

Sixty percent of total U.S. ammonia production capacity was concentrated in the States of Louisiana (40%), Oklahoma (14%), and Texas (6%), owing to large indigenous reserves of natural gas feedstock. Plants in several midwestern States accounted for another 16% of the total; with the remainder equally divided between the southern and southeastern States, and western States (12% each). Farmland Industries, Inc.; Arcadian Corp.; Terra International, Inc.; CF Industries, Inc.; and Union Chemical Co. (Unocal) accounted for 46% of total U.S. ammonia capacity, in order of importance *(See tables 1, 2, 3, and 4.)*

In mid-1994, Mississippi Chemical Corp. (MCC) of Yazoo City, MS, went public on the NASDAQ exchange. The firm had formerly operated under a private farm cooperative system. The new structure was designed to provide working capital needed for expansion. In mid-September 1994, MCC and Air Products & Chemicals, Inc., finalized an agreement whereby MCC would purchase Air Products' annual ammonium nitrate output of 240,000 tons at Pace Junction, FL, for resale over a period of 15 years. MCC was to transfer its proprietary AMTRATE ammonium nitrate technology to Air Products.

Dakota Gasification Co. of Beulah, ND, announced the construction of a 300,000-ton-per-year ammonia plant based on methane gas feedstock derived from lignite. A used ammonia plant was to be moved from Freeport-McMoRan's idle Fort Madison, IA, facility. Total ammonia capacity, including that already onsite, should approximate 310,000 tons per year. The first flue gas desulfurization unit based on ammoniation of sulfur dioxide to produce salable ammonium sulfate, was to be constructed using General Electric Environmental Systems' Inc. technology. The unit was designed to produce 180,000 tons per year of salable ammonium sulfate, to be marketed under contract by H. J. Baker and Bros. The project was scheduled to come on-stream in late-1996.

Terra Industries, Inc., purchased the Agricultural Minerals Corp. (AMC) nitrogen fertilizer facilities at Verdigris, OK, and Blytheville, AR, having a combined annual ammonia capacity of 1.3 million tons, and about 1.0 million tons of urea. The $400 million transaction, included about 300 million gallons of annual methanol capacity, which was to continue to be handled by the former AMC subsidiary, Beaumont Chemical Corp.

In mid-December 1994, Terra's ammonium nitrate plant near Sioux City, IA, was destroyed, and the ammonia plant damaged, when a blast occurred in the ammonium nitrate neutralizer section. Terra officials estimated that the ammonia plant would be out of service for about 1 year, while plans were formulated to rebuild the nitrogen solutions and ammonium nitrate section at a later date.

LaRoche Industries, Inc., negotiated a

joint-venture agreement to purchase a 50% interest in Cytec Industries' 400,000-ton-per-year ammonia plant at Fortier, LA, to be called Avondale Ammonia. LaRoche was to consume its share of the ammonia for fertilizer and industrial applications, while Cytec's applications were primarily for industrial purposes.

LaRoche was also upgrading and doubling the capacity of two nitric acid plants at Cherokee, AL, and adding 50,000 tons per year to ammonium nitrate capacity, in a $5 million project scheduled for completion by the fall of 1996. Nitrogen oxide emissions were to be reduced by 30%.

Arcadian Corp. was upgrading nitrogen production facilities at Augusta, GA, and Memphis, TN. The $16 million project was designed to improve energy efficiency and add incrementally to ammonia and nitrogen solutions capacity. The firm also planned a $78 million expansion project that, in aggregate, would increase urea and ammonia synthesis capacity at Memphis, TN; relocate its idle nitric acid and ammonium nitrate facility at Savannah, GA, to Lima, OH, for nitrogen solutions production, along with an ammonia plant retrofit at Clinton, IA, designed to reduce energy consumption.

Arcadian contracted IDM Environmental Corp. to dismantle and relocate an idle 140,000-ton-per-year nitric acid plant at Gibbstown, NJ, purchased in December 1993 from E.I. du Pont de Nemours & Co., to its facility at Geismar, LA. The plant was to provide product for industrial sales by early 1996. IDM was also dismantling Arcadian's idle ammonia plant at Lake Charles, LA, for shipment to Karachi, Pakistan.

Arcadian purchased an idle ammonia plant at Brea, CA, from Louisiana Chemical Equipment, that was closed by Unocal Corp. in 1989. The 250,000-ton-per-year plant was to be dismantled and moved to Arcadian's nitrogen and urea facility at Point Lisas, Trinidad.

Vigoro Corp.'s subsidiary Phoenix Chemical Co. increased ammonia capacity at East Dubuque, IL, by 4% to 260,000 tons per year in a cost effective retrofit that lowered energy consumption from 36 to 35 million Btu's per ton of ammonia.

Chevron Chemical Co. announced that its nitric acid and nitrogen solutions plant at Richmond, CA, would be permanently closed by mid-1995. Unocal was operating the 100,000-ton-per-year nitric acid plant and 200,000-ton-per-year liquid fertilizer plant under the provisions of a 5-year tolling agreement, and reportedly, had the right of first refusal to buy the plant, dismantle, and move it to another location. Ocelot Ammonia Co. of Kitimat, British Columbia, was reportedly entertaining offers for the plant because of its improved market potential on the West Coast.

El Dorado Chemical Co. was reconstructing a nitric acid facility purchased from the U.S. Army's ammunition production facility at Joliet, IL. The $12 million project was to increase nitric acid capacity at the firm's El Dorado, AR, by about 35% to 480,000 tons per year by early 1995. El Dorado produced fertilizer and industrial grade ammonium nitrate, and concentrated nitric acid for the industrial merchant market.

Apache Nitrogen Products, Inc., contracted Jacobs Engineering Group Inc. to reactivate a wholly owned nitric acid plant at St. David, AZ, that had been idle for 10 years. Capacity was increased 50% to 140,000 tons per year at the time of commissioning in May 1994.

Olin Corp. announced an expansion of its 150,000-ton-per-year nitric acid facility at Lake Charles, LA, to accommodate new toluene diisocyanate (TDI) capacity that was for polyurethane production.

Consumption

Finished nitrogen products produced from ammonia in the United States were allocated about 80% to fertilizers and 20% to the industrial sector. Urea was used as a direct application fertilizer and as a component in the popular urea-ammonium nitrate (UAN) fertilizer solutions containing 28% to 32% nitrogen (N). In the industrial sector, urea was used extensively as a protein supplement in ruminant animal feeds; for the production of urea-formaldehyde adhesives and for the synthesis of melamine plastics and resins.

Ammonium phosphate compounds were consumed principally as fertilizers for domestic consumption and export, although high purity materials found popular use as the active ingredient in fire extinguishers, and bulk agricultural grade materials were used as fire retardants for forest fires and other purposes.

Ammonium nitrate was used in solid and liquid fertilizers, and in industrial explosives and blasting agents most commonly prepared as ammonium nitrate-fuel oil solid mixtures (ANFO), and also in slurry and gel forms. Ammonium sulfate was used primarily as a fertilizer material, resulting predominately as a reaction by-product of caprolactam, the monomer for Nylon-6 fiber and plastics.

Nitric acid was used directly for myriad uses, including salt formation reactions to produce metal nitrates, and in metal degreasing, treating and pickling for the graphic and galvanic industries. Nitration reactions with benzene, toluene, and phenol, produce dyestuffs, pharmaceutical products, trinitrotoluene (TNT) explosives, and disinfectants, respectively. Esterification reactions with glycol, glycerol, and cellulose, produce nitroglycerine explosives (dynamite), celluloid and nitrocellulose lacquers. Oxidation reactions with toluene, p-xylene, and cyclohexanone, produce polyurethanes, polyester fibers and plastics, and polyamide fibers and plastics (Nylon), respectively.

Acrylonitrile is produced from propylene and ammonia, for acrylic fibers, high impact acrylonitrile-butadiene-styrene (ABS) plastics, and nitrile elastomers.

Ammonia is used to produce hydroxylamine sulfate, to synthesize cyclohexanone oxime, for caprolactam production, through the Beckman Rearrangement reaction. Depending upon the process, the by-product ammonium sulfate:caprolactam weight ratio ranges between 2:1 to 4:1. *(See table 5.)*

Other uses of ammonia are for the production of amines, cyanides, and methyl methacrylate polymers (plexiglass); liquid home cleaners, pulp and paper production, industrial refrigeration, and metallurgy.

U.S. nitrogen fertilizer applied for domestic consumption was up 12% to a record 11.5 million tons N in 1994. Consumption was up substantially owing to a significant increase in feedgrain acreage and the need to replenish nutrient deficient soils resulting from record summer flooding during the 1993 fertilizer year. Direct application anhydrous ammonia exhibited the largest increase. *(See table 6.)*

Net farm income in 1994 was estimated at $49.7 billion by the U.S. Department of Agriculture, compared with $43.4 billion in 1993. Net outlays for farm programs in 1994 was $10.3 billion.[7]

Stocks

U.S. producer stocks of nitrogen compounds in all identifiable forms were up by a moderate 3% between 1993 and 1994. *(See table 7.)*

Transportation

Ammonia was transported by refrigerated barge, rail, pipeline, and truck. Koch Industries operated the Gulf Central Ammonia Pipeline that extended about 3,060 kilometers (km)—1,900 miles—from the Gulf of Mexico into the Midwest, as far north as Iowa. The annual capacity of this pipeline was about 2 million tons, with storage capacity of more than 1 million tons.

Mapco Ammonia Pipeline Inc. operated Mapco Ammonia Pipeline and its sister company, Mid-America Pipeline, along a 1,770 km—1,098 mile—corridor that extended in a northeasterly direction from Borger, TX, in northern Texas, to Mankato, MN, in southern Minnesota. The Mapco pipeline had an annual capacity of about 1 million tons and about 500,000 tons of ammonia storage capacity.

CF Industries, Inc., and Cargill Fertilizer, Inc., were operating the Tampa Bay Pipeline system, a joint-venture ammonia pipeline that serves nitrogen compound and ammonium phosphate producers in Hillsborough and Polk Counties, FL.

Prices

Ammonia prices, f.o.b. barge, New Orleans, rose dramatically during January-June 1994, from about $140 per ton in early January, to an average of near $190 for the 6-month period. Prices rose even further during July-December, and at yearend were running about $245 per ton. Granular urea prices, f.o.b. U.S. Gulf, were relatively flat during the January-June period, but moved up substantially during the second-half of the year, and closed at a robust $220 per ton. UAN and ammonium nitrate prices also trended upwards as the year progressed. Diammonium phosphate prices were quoted at $190 per ton, f.o.b. central Florida, at yearend 1994, representing an increase of more than 20% compared with the same period in 1993. Ammonia and diammonium phosphate futures prices quoted on the Chicago Board of Trade (CBOT) reflected a firm price trend well into 1995. *(See table 8.)*

Foreign Trade

U.S. ammonia imports reached a record high 4.2 million product tons in 1994, and averaged about $173 per ton, c.i.f., compared with $128 per ton during the prior year. Ammonia exports were down substantially owing principally to the tight supply-demand situation. Trinidad and Tobago, Canada, Russia and the Ukraine, and Mexico, in order of importance, supplied about 90% of total U.S. ammonia import tonnage. *(See tables 9 and 10.)*

Ammonium phosphate exports were up 2.3 million tons, or 28% between 1993 and 1994, owing principally to a record imports by China. U.S. nitrogen product exports, in total, increased by 2.6 million tons, or 24% above 1993 levels.

U.S. nitrogen product imports in 1994 were up 1.5 million tons, or 18% compared with 1993 levels. Of this total, ammonia imports accounted for about 65% of the increase. There was a general increase in all major nitrogen imports between 1993 and 1994. The average c.i.f. price for all nitrogen imports averaged about $157 per ton in 1994 compared with $137 during the prior year. *(See tables 11 and 12.)*

World Review

Global ammonia production in 1994 increased 3% relative to 1993 levels, according to information reported by the International Fertilizer Industry Association (IFA), Paris, France. Total ammonia production was about 91.6 million metric tons N in 1994, based on data reported by the U.S. Bureau of Mines. Production increased in most regions except for the former U.S.S.R., where Russia and the Ukraine continued in a downward spiral established since the dissolution of the U.S.S.R. *(See table 13.)*

Geographically, about 40% of global ammonia production originated in the Far East, where China accounted for 55% of the regional total. North America—the United States and Canada—was 18% of the global total, with the United States accounting for 80% of the region. Countries in the former U.S.S.R. were 13% of the total; Western Europe, 11%; Latin America and the Middle East, 6% each; Eastern Europe, 5%; and Africa and Oceania, about 1% each.

Ammonia exports were up 11% to 10 million tons N between 1993 and 1994, with Russia and the Ukraine, Trinidad and Tobago, Canada, and Mexico accounting for more than 60% of the total, in order of importance. Several countries in Western Europe and the Middle East shipped most of the remainder. The United States imported 36% of global ammonia trade, followed by several countries in Western Europe (34%) and the Far East (15%). The remainder was imported by several countries in other regions around the globe.

Global urea production was 37.6 million tons N in 1994, or 3% above 1993 levels, and represented about 40% of world ammonia N production. Approximately 52% of world urea production was from the Far East, with China, India, Indonesia, Pakistan, and Bangladesh dominating regional production, in order of importance. North American production was 13% of the total, with the United States accounting for about 70% of the region; the Middle East, 10%; the former U.S.S.R.—principally Russia and the Ukraine—9%; Western Europe, 6%; Eastern Europe and Latin America, 5% each; with Africa and Oceania accounting for the remainder.

World urea trade rose 7% to 10 million tons N between 1993 and 1994. Russia and the Ukraine, in combination, accounted for 25% of total shipments, while the former U.S.S.R., in total, was 27% of global urea trade. Saudi Arabia, Qatar, and several other countries in the Middle East shipped 22% of the total; Canada and the United States, 13%; Indonesia and other countries in the Far East, 12%; Western Europe, 10%; Eastern Europe, 9%; and Latin America, 6%. Africa and Oceania shipped minor tonnages.

China, the United States, India, and Vietnam, accounted for 51% of global urea imports, in order of importance. Urea imports in Western Europe were up 48% compared with 1993 levels, owing to large volume increases in France, Germany, Italy, and Spain. Urea imports in the Middle East were off by 63% owing to major declines in Syria and Turkey. On a regional basis, countries in the Far East accounted for 48% of global urea imports, North America and Western Europe, 15% each; Latin America, 11%; Oceania, 3%; Africa and the Middle

East, 2% each; with Eastern Europe and unidentified locations accounting for the remainder.

Canada.—High international prices for ammonia and low prices for Canadian natural gas generated renewed interest in reactivating an idle ammonia plant and debottlenecking three others. Ammonia N capacity was to increase by 500,000 tons per year.

FarEast.—**China.**—Fifteen ammonia-urea projects totaling 4 million tons per year N have been identified as either under construction, contracted, or planned in several provinces. Of this number, 11 complexes (3 million tons N) were expected to be commissioned during the next 5 years. Many new ammonia plants were to use coal or heavy fuel-oil as feedstock and fuel. The reduction or removal of subsidies on coal production and transportation have been announced.

A 330,000-ton-per-year ammonia and matching urea plant were expected to be commissioned in 1996 on Hainan Island. The Hainan complex should logically supply China, but logistical factors may favor exports. Large natural gas reserves have been identified offshore near Hainan Island; thus, additional plants could be built in the future, even though most will reportedly be used for power generation in South China and in the Hong Kong area.

Presently, China relies heavily on inefficient ammonium bicarbonate for its nitrogen supply (7.9 million tons N in 1993). World Bank analysts estimate that up to 40% of the ammonium bicarbonate N is lost to the atmosphere during handling and application. Production is costly and relies exclusively on anthracite feedstock that is produced in only two Chinese provinces. Consequently, ammonium bicarbonate production may be cut back when new capacity comes onstream.

India.—Urea imports in 1994 reached a record 1.3 million tons N. Two new plants were commissioned in 1994, and a third plant should be completed in 1995. Another five new ammonia-urea projects totaling 1.1 million tons per year of urea N were scheduled for completion by 1998. The plants will be equally divided between natural gas and naphtha feedstocks, in spite of persisting gas curtailments and uncertainties concerning future gas policy. Modernization of existing plants run by the Fertilizer Corp. of India and by Hindustan Fertilizer Corp. also have been announced.

New urea production capability may grow faster than demand, and as a consequence, urea imports could potentially decline in the next few years. The future fertilizer policy in India remains uncertain, however, as the present urea subsidy program could change pending the outcome of the 1996 elections.

Indonesia.—Ammonia and urea surplus availability for export should be increased in 1995 owing to the recent commissioning of two new plants. The Indonesian Government has approved another two new ammonia-urea projects that are to be built during the next 4 years at Cikampek, Java, and at Lhok Seumawe, Sumatra, together with a new urea plant at Bontang, Kalimantan. These new plants are planned to be commissioned by 1998.

Pakistan.—Natural gas supplies have been allocated for the expansion of annual urea capacity by 0.7 million tons N in three new plants by 1998. Pakistan should begin to export small tonnages of urea in 1995, and by 1998, should have a significant surplus available for export.

Thailand.—Construction was scheduled to commence on a 0.2 million-ton-per-year urea N plant at Rayong. This was to be the world's first urea complex based on imported ammonia. Carbon dioxide feedstock was to be sourced from a natural gas field. An ammonia terminal was under construction to supply this plant, a mixed fertilizer facility, and a caprolactam plant, all to be built in the Rayong vicinity. An ammonia plant was planned in the more distant future.

Vietnam.—Urea imports continued to increase and, in 1994, were 0.8 million tons N, or 25% above 1993 levels. Domestic production is currently limited to a 1962 Chinese design medium scale ammonia-urea complex using anthracite as feedstock and fuel, in Northern Vietnam. An expansion of this facility was under consideration in spite of its obsolete technology and high costs.

In addition to associated gas that is currently flared, significant gas resources have been identified in the off-shore Bach Ho field and perhaps in other fields off the coast of Southern Vietnam. Consequently, it has been proposed that a joint project should be built on the southern coast at Vung Tau, involving a natural gas fired powerplant in which feedstock would be valued at $3 per million Btu, together with a 330,000-ton-per-year ammonia and 580,000-ton-per-year urea plant that would be charged $1.50 per million Btu for feedstock.

Former U.S.S.R.—The region continued as the world's leading exporter of ammonia and urea in 1994. Most of the product was produced in Russia and the Ukraine, in order of importance. Ammonia exports were 4.2 million tons product, and urea, 5.8 million tons product. These tonnages were about the same as in 1993.

In Russia, ammonia plants ran at 59% of capacity and urea plants at a rate of 69%. In Ukraine, ammonia and urea operating rates were 64% and 83%, respectively. About 75% of ammonia exports were from Russia, 20% from the Ukraine, with the remainder coming from Byelorussia and the Baltic states. About 70% was shipped from the Black Sea port at Yuzhnyy, Ukraine, and 30% from the Baltic port at Ventspills, Latvia. Ammonia exports were expected to be up about 15% to 5 million tons product in 1995.

Russia accounted for 55% of urea exports, the Ukraine, 40%; with Belarus, Uzbekistan, and the Baltic Republics accounting for the remainder. Exports through Yuzhnyy were 65% of the total. Urea exports were expected to be up between 5% and 20% in 1995.

The cost of natural gas continued to increase in both Russia and the Ukraine. In mid-1995, gas costs approximated $0.92 per million Btu in Russia and $1.90 per million Btu in Ukraine. For comparison, gas costs a year ago in Russia and the Ukraine were approximately $0.65 and $1.50, respectively. Growing involvement of the Russian gas company GAZPROM in the fertilizer industry, has improved the stability of gas supplies and of prices. In the Ukraine, the availability of natural gas was much improved, and price reductions were expected to be announced in the near future.

Latin America.—**Argentina.**—A 0.3-million-ton-per-year N ammonia-urea project was planned in Neuquen province during the next 5 years.

Trinidad and Tobago.—Farmland Industries, Inc., and Mississippi Chemical Corp. contracted the M. W. Kellogg Co. of Houston, TX, to construct the largest single train ammonia plant in the world. The 600,000-ton-per-year, $300 million facility was to use Kellogg's new gas efficient Advanced Ammonia Process (KAAP), and was scheduled on-stream in late-1997.

Arcadian Corp. was adding 300,000 tons

per year of ammonia capacity at its Point Lisas complex by 1996, based on the relocation of a plant from the United States.

Middle East.—The only firm ammonia-urea project at present was in Qatar where 0.4 million tons N was scheduled onstream in early-1997. Bids have been requested for a 0.9 million ton N ammonia-urea project in Oman.

Western Europe.—France, Italy, the Netherlands, and Spain each closed an ammonia plant in 1994. An idle plant at Thessaloniki, Greece, was recommissioned.

Current Research and Technology

Personnel at the U.S. Bureau of Mines Pittsburgh Research Center were studying methods of desensitizing ammonium nitrate to detonation. One objective is to determine a diluent and a level of dilution that minimizes the usefulness of ammonium nitrate as an explosive while retaining its benefit as a fertilizer. The Bureau has found that ammonium nitrate containing 20% urea will not detonate based on the simple addition of fuel oil.[8]

Various additives have been proposed to desensitize ammonium nitrate to detonation, including the production of calcium ammonium nitrate, a mixture containing 78.5% ammonium nitrate and 21.5% calcium carbonate in the form of dolomitic limestone, and used in Ireland and several other European countries as a counter-terrorist measure. About 30 years ago, Samuel J. Porter, a hazardous chemicals consultant from Woodbridge, VA, was awarded a patent claiming that the addition of 5% to 10% by weight of diammonium or monoammonium phosphate will prevent ammonium nitrate fertilizer from exploding.

Independent testing of ammonium phosphate and calcium carbonate additives by the consulting firm, Failure Analysis Associates of Menlo Park, CA, however, revealed that none of the materials eliminated the explosiveness of ammonium nitrate. Furthermore, thermodynamic data published by Mr. Peter G. Urben, editor of "Bretherick's Handbook of Reactive Chemical Hazards," show that heat released from the detonation of a mixture of ammonium nitrate and ammonium phosphate is up to 60% greater than that from ammonium nitrate alone. Ammonium sulfate additives give similar results.[9]

Outlook

Global supply-demand balances developed by IFA in May 1995, suggest that surplus ammonia availability may tighten sharply, from 4% of supply capability in 1995 (4 million tons N) to less than 1% (1 million ton N surplus) by 1999. The global urea supply-demand situation was forecast to remain in balance, and to become tighter with time, declining from 4% of supply capability in 1995 (1.5 million tons N), to about 3% by 1999 (1.3 million tons N).[10]

IFA's forecast was based on the most probable scenario at the time, which suggested a persistence of low operating rates in the former U.S.S.R. and Eastern Europe, owing to a multiplicity of downside factors, along with a decline in ammonium bicarbonate production in China, that would favor a gradual increase in Chinese urea imports.

Significant ammonia and urea surpluses could develop at the global level, if operating levels in the former U.S.S.R. gradually improve during the forecast period, and China were to continue to produce large quantities of ammonium bicarbonate. Also, overreaction to significantly higher straight nitrogen compound, and ammonium phosphate prices in 1994, could precipitate a new round of global N capacity expansion that may accentuate oversupply.

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TABLE 1
SALIENT AMMONIA STATISTICS 1/ 2/

(Thousand metric tons of contained nitrogen unless otherwise specified)

	1990	1991	1992	1993	1994 p/
United States:					
Production	12,700	12,800	13,400 r/	12,600 r/	13,400
Exports	482	580	354	378	215
Imports for consumption	2,670	2,740	2,690	2,660	3,450
Consumption, apparent 3/	14,900	14,800	15,600 r/	15,100 r/	16,500
Stocks, Dec. 31: Producers'	797	936	1,060	852 r/	956
Average annual price per ton product, f.o.b. gulf coast 4/	$106	$117	$106	$121	$211
Net import reliance 5/ as a percent of apparent consumption	15	14	14	17 r/	19
Natural gas price: Wellhead 6/	$1.71	$1.64	$1.74	$2.03 r/	$1.83
World:					
Production	97,500 r/	93,800 r/	93,600 r/	91,700 r/	91,600 e/
Trade 7/	10,000	9,590	9,270 r/	8,990 r/	10,000

e/ Estimated. p/ Preliminary. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Synthetic anhydrous ammonia, calendar year data, Bureau of the Census; excludes coke oven byproduct.

3/ Calculated from production, plus imports minus exports, and industry stock changes.

4/ Green Markets, Fertilizer Market Intelligence Weekly, Pike & Fischer, Inc.

5/ Defined as imports minus exports, adjusted for industry stock changes.

6/ Monthly Energy Review, U.S. Department of Energy. Average annual cost at wellhead in dollars per thousand cubic feet.

7/ International Fertilizer Industry Association statistics--World Anhydrous Ammonia Trade.

TABLE 2
FIXED NITROGEN PRODUCTION IN THE UNITED STATES 1/

(Thousand metric tons of contained nitrogen)

	1990	1991	1992	1993	1994 p/
Anhydrous ammonia, synthetic: 2/					
Fertilizer	11,600	11,600	12,000 r/	11,300 r/	11,600
Nonfertilizer	1,110	1,240	1,350	1,320 r/	1,750
Total	12,700	12,800	13,400 r/	12,600 r/	13,400
Byproduct ammonia, coke plants: 3/					
Ammonium sulfate e/	47	42	41	40	40
Ammonia liquor e/	5	4	4	4	4
Total e/	52	45	44	44	44
Grand total	12,700	12,800	13,400 r/	12,600 r/	13,400

e/ Estimated. p/ Preliminary. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Current Industrial Reports, MA28B, M28B, and MQ28B Bureau of the Census.

3/ Quarterly Coal Report, U.S. Department of Energy. Production estimates based on reported coke production trend.

TABLE 3
MAJOR DOWNSTREAM NITROGEN COMPOUNDS PRODUCED IN THE UNITED STATES 1/ 2/

(Thousand metric tons)

Compound	1990	1991	1992	1993 r/	1994 p/
Urea:					
Gross weight	7,450	7,380	7,950 r/	7,520	7,320
Nitrogen content	3,430	3,390	3,660 r/	3,460	3,370
Ammonium nitrate:					
Gross weight	7,000	7,090	7,240 r/	7,490	7,990
Nitrogen content	2,450	2,480	2,530 r/	2,620	2,800
Ammonium phosphates: 3/					
Gross weight	15,900	16,400	17,200 r/	15,900	15,800
Nitrogen content	2,670	2,710	2,920	2,680	2,660
Ammonium sulfate: 4/					
Gross weight	2,290	2,040	2,170	2,200	2,310
Nitrogen content	485	432	460	466	489
Nitric acid, direct use: 5/					
Gross weight	1,680	1,610	1,680 r/	1,840	1,710
Nitrogen content	374	357	373 r/	408	381
Acrylonitrile:					
Gross weight	1,370	1,200	1,280	1,130	1,400
Nitrogen content	363	318	338	298	369
Caprolactam:					
Gross weight	626	582	625	650	763
Nitrogen content	78	73	78	81	95
Total:					
Gross weight	36,300	36,300	38,200 r/	36,700	37,300
Nitrogen content	9,850	9,770	10,400	10,000	10,200

p/ Preliminary. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Ranked in relative order of importance.

3/ Diammonium phosphate (DAP), monoammonium phosphate (MAP), and other ammonium phosphates.

4/ Excludes coke plant ammonium sulfate.

5/ Gross nitric acid production netted for use in production of ammonium nitrate.

Sources: Bureau of the Census and International Trade Commission.

TABLE 4
DOMESTIC PRODUCERS OF ANHYDROUS AMMONIA IN 1994 1/

(Thousand metric tons per year of ammonia)

Company	Location	Capacity 2/
Air Products and Chemicals Inc. 3/	New Orleans, LA 4/	263
Do.	Pace Junction, FL 5/	45
Allied Chemical Corp.	Hopewell, VA 4/	392
Avondale Ammonia 6/	Fortier, LA	404
Dakota Gasification Co.	Beulah, ND	22
Arcadian Corp.	Augusta, GA	522
Do.	Clinton, IA	236
Do.	Geismar, LA 4/	500
Do.	LaPlatte, NE	177
Do.	Lima, OH 7/	494
Do.	Woodstock, TN	308
Borden Chemical Co.	Geismar, LA	386
Carbonaire Co. Inc. 8/	Palmerton, PA	--
CF Industries Inc.	Donaldsonville, LA	1,630
Chevron Chemical Co.	El Segundo, CA	18
Do.	St. Helens, OR	77
Coastal Chem, Inc.	Cheyenne, WY	167
Cominco American Inc.	Borger, TX 4/	386
Diamond Shamrock	Dumas, TX	127
E.I. du Pont de Nemours & Co. Inc.	Beaumont, TX	445
Farmland Industries Inc.	Beatrice, NE	236
Do.	Dodge City, KS	235
Do.	Enid, OK	923
Do.	Fort Dodge, IA	220
Do.	Hastings, NE	(9/)
Do.	Lawrence, KS	408
Do.	Pollock, LA 4/	454
First Mississippi Corp. (Ampro)	Donaldsonville, LA	440
Green Valley Chemical Corp.	Creston, IA	32
IMC-Agrico 10/	Donaldsonville, LA	480
Koch Industries	Sterlington, LA	998
Jupiter Chemicals	West Lake, LA	27
LaRoche Industries Inc.	Cherokee, AL	159
Mississippi Chemical Corp.	Yazoo City, MS	454
Monsanto Co.	Luling, LA	445
Phoenix Chemical Co.(Vigoro)	East Dubuque, IL	260
PPG Industries Inc. 11/	Natrium, WV	--
J.R. Simplot Co.	Pocatello, ID	93
Terra International, Inc.	Port Neal, IA 12/	308
Do.	Blytheville, AR 13/	363
Do.	Verdigris, OK 13/	907
Do. (Oklahoma Nitrogen)	Woodward, OK	408
Trial Chemical Co. 14/	Donaldsonville, LA	408
Union Chemical Co. (Unocal)	Kenai, AK	1,130
Wil-Grow Fertilizer Co.	Pryor, OK	85
Total		16,100

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to total shown.
2/ Engineering design capacity adjusted for 340 days per year of effective production capability.
3/ Closed late-1994 to early-1995.
4/ Revamp and/or retrofit.
5/ Capacity cut 50% at yearend 1993.
6/ Joint venture between American Cyanamid and LaRoche Industries formed in 1994.
7/ Purchased from B.P. Intl. Ltd. in 1993.
8/ Closed in 1993.
9/ Plant (140,000 tons per year) mothballed.
10/ Joint venture formed mid-year 1993; Freeport-McMoRan owns Agrico.
11/ Closed in 1994.
12/ Plant damaged Dec. 1994 as a result of explosion in Ammonium Nitrate section.
13/ Former Agricutural Minerals (AMC) plants sold to Terra International in 1994.
14/ Joint venture between First Mississippi Corp. and Mississippi Chemical Corp..

Sources: International Fertilizer Development Center (IFDC); North American Fertilizer Capacity, Ammonia, Apr. 1995. Blue, Johnson and Associates, North American NPK Plants and Capacities, Foster City, CA.

TABLE 5
CONSUMPTION TRENDS FOR MAJOR NITROGEN COMPOUNDS PRODUCED IN THE UNITED STATES 1/ 2/

(Thousand metric tons of contained nitrogen)

	1990	1991	1992	1993	1994 p/
Fertilizer materials:					
Urea:					
Solid	1,920	1,870	1,900 r/	1,770	1,860
Solution	1,160	1,140	1,320	1,300 r/	1,150
Total	3,080	3,010	3,230 r/	3,070 r/	3,000
Ammonium phosphates 3/	2,670	2,710	2,920	2,680 r/	2,660
Ammonium nitrate:					
Solid	697	696	702 r/	707 r/	707
Solution	1,020	1,170	1,190 r/	1,240 r/	1,320
Other 4/	68	15	2	-1 r/	-- e/
Total	1,780	1,880	1,900 r/	1,950	2,030
Ammonium sulfate:					
Synthetic and byproduct	485	432	460	466 r/	489
Coke oven byproduct e/	52	45	44	44	44
Total	537	477	504	510 r/	533
Total fertilizer	8,070	8,080	8,590	8,210 r/	8,220
Nonfertilizer materials:					
Urea: 3/					
Feed	82	95	104	110 r/	104
Industrial	270	289	329	279 r/	259
Total	352	384	433	389 r/	363
Ammonium nitrate 3/	667	605	636	673 r/ e/	771 e/
Nitric acid	374	357	373 r/	408 r/	381
Acrylonitrile	363	318	338	298 r/	369
Caprolactam	78	73	78	81 r/	95
Total nonfertilizer	1,830	1,740	1,860	1,850 r/	1,980
Grand total	9,900	9,820	10,400	10,100 r/	10,200

e/ Estimated. p/ Preliminary. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Ranked in relative order of importance.

3/ Solid and solution.

4/ Unaccounted distribution.

Sources: Current Industrial Reports, MA28B and MQ28B, Bureau of the Census; and, International Trade Commission.

TABLE 6
U.S. NITROGEN FERTILIZER CONSUMPTION, BY PRODUCT TYPE 1/ 2/

(Thousand metric tons nitrogen)

Fertilizer material 3/	1993	1994 p/
Single-nutrient:		
Anhydrous ammonia	3,260 r/	4,120
Nitrogen solutions 4/	2,370 r/	2,420
Urea	1,640	1,680
Ammonium nitrate	592	609
Ammonium sulfate	166	180
Aqua ammonia	61	78
Other 5/	134 r/	221
Total	8,220 r/	9,310
Multiple-nutrient 6/	2,120 r/	2,160
Grand total	10,300	11,500

p/ Preliminary. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Fertilizer years ending June 30.

3/ Ranked in relative order of importance by product type.

4/ Principally urea-ammonium nitrate (UAN) solutions.

5/ Includes other single-nutrient nitrogen materials, all natural organics, and statistical discrepencies.

6/ Various combinations of nitrogen (N), phosphate (P), and potassium (K): N-P-K, N-P, and N-K.

Source: Commercial Fertilizers. Prepared as a cooperative effort by the Tennessee Valley Authority, The Fertilizer Institute, and the Association of American Plant Food Control Officials, Dec. 1994.

TABLE 7
U. S. PRODUCER STOCKS OF FIXED NITROGEN COMPOUNDS AT YEAREND 1/ 2/

(Thousand metric tons nitrogen)

Material 3/	1993	1994 p/
Ammonia	852 r/	956
Nitrogen solutions 4/	305	295
Urea	226 r/	175
Ammonium nitrate	96 r/	90
Ammonium phosphates 5/	88 r/	87
Ammonium sulfate	34	48
Total	1,600 r/	1,650

p/ Preliminary. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Calendar year ending Dec. 31.

3/ Ranked in relative order of importance.

4/ Urea-ammonium nitrate and ammoniacal solutions.

5/ Diammonium, monoammonium, and other ammonium phosphates.

Source: Current Industrial Reports, MA28B and MQ28B, Bureau of the Census.

TABLE 8
PRICE QUOTATIONS FOR MAJOR NITROGEN COMPOUNDS AT YEAREND

(Per metric ton product)

Compound	1993	1994
Ammonium nitrate: f.o.b. Corn Belt 1/	$138-$149	$165-$176
Ammonium sulfate do.	133-147	125-149
Anhydrous ammonia:		
F.o.b Corn Belt	157-171	254-265
F.o.b. gulf coast 2/	143-146	240-254
Diammonium phosphate: F.o.b. central Florida	152-154	184-190
Nitrogen solutions (28% to 32%):		
F.o.b. South Central 3/	99-112	117-124
Urea:		
F.o.b. Corn Belt, prilled	141-165	204-215
F.o.b. gulf coast, granular 2/	139-141	219-226
F.o.b. gulf coast, prilled 2/	128-130	204-213

1/ Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio.

2/ Barge, New Orleans.

3/ Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Tennessee, and Texas.

Source: Green Markets, Fertilizer Market Intelligence Weekly, Dec. 20, 1993, and Jan. 2, 1995.

TABLE 9
U.S. EXPORTS OF ANHYDROUS AMMONIA, BY COUNTRY 1/

(Thousand metric tons ammonia)

Country	1993	1994 p/
Korea, Republic of	284	201
Mexico	6	27
Australia	--	25
Canada	21	2
China	(2/)	1
Taiwan	13	1
Costa Rica	36	(2/)
Jamaica	2	1
Suriname	2	1
Morocco	50	--
South Africa, Republic of	23	--
Norway	21	--
Other 3/	2	2
Total	460	261

p/ Preliminary.

1/ Value data suppressed by Bureau of the Census. Ranked in relative order of importance by country and geographics.

2/ Less than 1/2 unit.

3/ Fifteen countries, principally in Latin America.

Source: Bureau of the Census.

TABLE 10
U. S. IMPORTS OF ANHYDROUS AMMONIA, BY COUNTRY AND REGION 1/

(Thousand metric tons ammonia)

Country/Region 2/	1993 Gross weight	1993 Value 3/ (thousands)	1994 p/ Gross weight	1994 p/ Value 3/ (thousands)
Trinidad and Tobago	986	$127,000	1,380	$252,000
Canada	979	129,000	1,130	161,000
Russia and Ukraine 4/	631 5/	81,900	783	145,000
Latvia	25 5/	NA	70	15,200
Mexico	285	38,300	526	93,200
Venezuela	82	10,500	78	14,000
Brazil	--	--	33	6,180
Middle East 6/	141	14,600	138	27,800
West Europe 7/	53	7,330	38	8,040
Algeria	50	6,010	12	2,760
Japan	(8/)	21	(8/)	27
India	--	--	3	385
Total	3,230	415,000	4,200	725,000

p/ Preliminary. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Ranked in relative order of importance by country and region.

3/ C.i.f. value.

4/ Independent republics of the former U.S.S.R., effective Jan. 1992.

5/ Tonnage data based on the U.S. Bureau of Mines industry intelligence. Data suppressed by Bureau of the Census since Jan. 1, 1989.

6/ Saudi Arabia, Bahrain, Kuwait, and Qatar, in order of importance.

7/ The Netherlands, Germany, Norway, France, the United Kingdom, and Portugal, in order of importance.

8/ Less than 1/2 unit.

Sources: Bureau of the Census and U.S. Bureau of Mines.

TABLE 11
U.S. EXPORTS OF MAJOR NITROGEN COMPOUNDS IN 1994 1/

(Thousand metric tons)

Compound	1993			1994		
	Gross weight	Nitrogen content	Value 2/ (thousands)	Gross weight	Nitrogen content	Value 2/ (thousands)
Fertilizer materials:						
Ammonium nitrate 3/	66	22	NA	55	18	NA
Ammonium sulfate 3/	757	159	NA	762	160	NA
Anhydrous ammonia	460	378	NA	261	215	NA
Diammonium phosphate	7,240	1,300	NA	9,190	1,660	NA
Monoammonium phosphate	1,100	121	NA	1,480	162	NA
Nitrogen solutions	28	8	NA	119	35	NA
Sodium nitrate	2	(4/)	NA	2	(4/)	NA
Urea	659	303	NA	912	419	NA
Mixed chemical fertilizers 5/	329	52	NA	387	61	NA
Other ammonium phosphates 6/	69	11	NA	54	8	NA
Other nitrogenous fertilizers 7/	171	7	NA	189	9	NA
Total	10,900	2,370	NA	13,400	2,740	NA
Industrial chemicals:						
Ammonia, aqua (ammonia content)	20	16	$1,620	25	20	$1,860
Ammonium compounds 8/	9	3	8,840	14	4	10,900
Ammonium phosphate (ortho)	(4/)	(4/)	152	(4/)	(4/)	27
Potassium cyanide	(4/)	(4/)	1,130	(4/)	(4/)	765
Sodium cyanide	62	17	50,900	69	20	63,600
Other cyanides and cyanates	1	(4/)	6,260	3	1	8,710
Hydrazine, hydroxylamine and related inorganic salts	13	6	21,300	16	8	33,700
Bismuth/silver nitrates	(4/)	(4/)	7,230	(4/)	(4/)	13,900
Potassium nitrate	18	3	4,440	6	1	3,520
Other nitrates	4	1	7,850	9	2	6,480
Nitric/sulfonitric acids	15	3	5,280	17	3	6,190
Nitrates	7	1	4,120	9	2	6,330
Total	149	50	119,000	169	59	156,000
Grand total	11,000	2,410	NA	13,600	2,800	NA

NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Export values f.a.s.

3/ Includes industrial chemical products.

4/ Less than 1/2 unit.

5/ Harmonized codes 3105.10.0000 and 3105.20.0000.

6/ Codes 3105.51.0000, 3105.59.0000, and 3102.70.0000.

7/ Codes 3101.00.0000, 3102.29.0000, 3102.60.0000, and 3102.90.0000.

8/ Carbonates, chloride, fluorides, and tungstate.

Source: Bureau of the Census. Effective Jan. 1, 1989, U.S. exports and imports were reported under the new international Harmonized Commodity Description and Coding System (Harmonized System).

TABLE 12
U.S. IMPORTS OF MAJOR NITROGEN COMPOUNDS IN 1994 1/

(Thousand metric tons)

Compound	1993			1994		
	Gross weight	Nitrogen content	Value 2/ (thousands)	Gross weight	Nitrogen content	Value 2/ (thousands)
Fertilizer materials:						
Ammonium nitrate 3/	485	162	$58,500	612	205	$74,000
Ammonium nitrate-limestone mixtures	12	3	1,250	41	11	5,190
Ammonium sulfate 3/	367	77	32,000	455	95	38,000
Anhydrous ammonia 4/	3,230	2,660	415,000	4,200	3,450	725,000
Calcium nitrate	(5/)	(5/)	11,900	(5/)	(5/)	13,800
Diammonium phosphate	38	7	7,100	15	3	4,270
Monoammonium phosphate	157	17	26,000	203	23	41,400
Nitrogen solutions	391	117	38,200	312	93	31,500
Potassium nitrate	28	4	8,750	16	2	5,240
Potassium nitrate-sodium nitrate mixtures	39	5	6,570	45	7	6,810
Sodium nitrate	123	20	20,900	98	15	15,700
Urea	2,960	1,360	396,000	3,160	1,450	436,000
Mixed chemical fertilizers 6/	200	24	32,200	212	25	33,000
Other ammonium phosphates 7/	92	15	10,800	211	34	25,100
Other nitrogenous fertilizers 8/	141	28	25,500	145	28	25,500
Total	8,270	4,500	1,090,000	9,730	5,450	1,480,000
Industrial chemicals:						
Ammonia, aqua (ammonia content)	11	3	751	13	4	1,330
Ammonium compounds 9/	15	4	22,500	15	4	20,500
Calcium cyanamide	1	(5/)	782	(5/)	(5/)	270
Potassium cyanide	1	(5/)	1,360	1	(5/)	1,550
Sodium cyanide	3	1	3,450	3	1	3,100
Other cyanides and cyanates 10/	4	1	4,950	4	1	5,430
Hydrazine, hydroxylamine and related salts	2	1	5,650	3	1	8,250
Bismuth/silver nitrates	(5/)	(5/)	2,150	(5/)	(5/)	10,000
Strontium/other nitrates	4	1	3,450	3	1	2,610
Nitric/sulfonitric acids	10	2	2,650	11	3	3,010
Sodium/other nitrites	2	(5/)	1,090	2	(5/)	1,260
Total	51	12	48,800	54	14	57,300
Grand total	8,320	4,510	1,140,000	9,780	5,460	1,540,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Import values c.i.f.

3/ Includes industrial chemical products.

4/ Anhydrous ammonia tonnage data for the former U.S.S.R. reported by the U.S. Bureau of Mines; includes industrial ammonia.

5/ Less than 1/2 unit.

6/ Harmonized codes 3105.10.0000 and 3105.20.0000.

7/ Codes 3105.51.0000, 3105.59.0000, and 3105.40.0050.

8/ Codes 3101.00.0000, 3102.29.0000, 3102.60.0000, 3102.90.0000, and 3105.90.0050.

9/ Carbonates, chloride, fluorides, and tungstate (exports and imports); bromide, molybdate, orthophosphate, and perrhenate (imports).

10/ Data for code 2837.19.0020 (other cyanides) deleted or omitted by Bureau of the Census.

Source: Bureau of the Census. Effective Jan. 1, 1989, U.S. exports and imports were reported under the new international Harmonized Commodity Description and Coding System (Harmonized System).

TABLE 13
AMMONIA: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons of contained nitrogen)

Country	1990	1991	1992	1993	1994 e/
Afghanistan e/	40	40	40	30 r/	30
Albania e/	100	80	15	15	15
Algeria	288	269	438	380	400
Argentina	70	75 r/	72 r/	72 r/	72
Australia	385	414 e/	391 e/	398 r/	400
Austria e/	410	400	400	400	400
Bahrain	325	320 r/	323 r/	348	338 3/
Bangladesh 4/	701	667	937	991	995
Belarus	XX	XX	916	619	500
Belgium	274	272	514	535 r/	500
Bosnia and Herzegovina e/	XX	XX	5	2	1
Brazil	938	940 e/	940 e/	914	940
Bulgaria	1,310	1,090	905 r/	750 e/	800
Burma	77	111	110 r/ e/	110 r/ e/	130
Canada	3,050	3,020	3,100	3,410	3,470 3/
China e/	17,500	18,000	18,000	19,000	19,000
Colombia	90	92	86	99	90
Croatia e/	XX	XX	300	300	300
Cuba e/	140	140	135	135	130
Czech Republic	XX	XX	XX	149	150
Czechoslovakia 5/	793	551	385 e/	XX	XX
Egypt	735	863	943	941	940
Estonia	XX	XX	115	45	45
Finland	23	24	10 e/	10 e/	10
France	1,590	1,600	1,850	1,870 r/	1,800
Germany:					
Eastern states	1,020 r/	XX	XX	XX	XX
Western states	1,670	XX	XX	XX	XX
Total	2,690 r/	2,120	2,110	2,100 r/	2,130 3/
Georgia	XX	XX	96	58	35
Greece	257	210	140	57	55
Hungary	443 r/	261 r/	152 r/	237 r/	230
Iceland	8	8 r/	9	9 e/	9
India 6/	7,010	7,130	7,450 r/	7,350 r/	7,400
Indonesia	2,790	2,710	2,690	2,890	2,800
Iran	420	468	664 r/	723 r/	696 3/
Iraq e/	240	40	200	500 r/	500
Ireland	395 e/	429	384	367	380
Israel 4/	42	35	37	41	41
Italy	1,200	1,150	1,100 e/	729	800
Japan	1,530	1,550	1,600	1,450	1,450
Kazakhstan	XX	XX	220	231	200
Korea, North e/	500	550	550	600	600
Korea, Republic of	411	407	442	450 r/ e/	460
Kuwait	292	--	140	320	325
Libya e/	200	200	200	200	200
Lithuania	XX	XX	275	130	130
Malaysia	229	286	331	334 r/	334
Mexico	2,160	2,220	2,200	1,760	2,030 3/
Netherlands	3,190	3,030	2,590	2,470 r/	2,500
New Zealand e/	70	70	68 3/	78 r/	78
Nigeria	405	367	360 e/	350 e/	350
Norway	431	384	343	315	300
Pakistan	1,210	1,150	1,140	1,450	1,450
Peru e/	90	95	90	90	90
Poland	1,960	1,530	1,490	1,420 r/	1,500
Portugal	198	198	100	91	100
Qatar	584	569	622	516	516
Romania	1,790	1,130 r/	1,420 r/	1,400 r/ e/	1,400
Russia	XX	XX	8,790	8,140	7,500
Saudi Arabia	942	827	904	1,100	1,100
Serbia and Montenegro	XX	XX	148	100 r/	100
Slovakia	XX	XX	XX	263	250

See footnotes at end of table.

TABLE 13--Continued
AMMONIA: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons of contained nitrogen)

Country	1990	1991	1992	1993	1994 e/
South Africa, Republic of	456	457	541	607	600
Spain	466	557	479	354	360
Switzerland	32	33	31	28	30
Syria	104	17	81	67	65
Taiwan	216	243	224 e/	220	215
Tajikistan e/	XX	XX	50 r/	40	30
Trinidad and Tobago	1,520	1,600 r/	1,570	1,460	1,560
Turkey	373	357	344	326 r/	350
Turkmenistan	XX	XX	25	32	25
U.S.S.R. 7/	18,200	17,100	XX	XX	XX
Ukraine	XX	XX	3,910	3,240	2,500
United Arab Emirates	295	286	275 r/	288 r/	300
United Kingdom	1,150	1,010	869	873	900
United States 8/	12,700	12,800	13,400 r/	12,600 r/	13,400 3/
Uzbekistan	XX	XX	1,310	1,110	1,100
Venezuela	557	450	404	535	505 3/
Vietnam e/	36	30 r/	45	52 3/	53
Yugoslavia 9/	802	700 e/	XX	XX	XX
Zambia	4	5	7 e/	10	10
Zimbabwe e/	63	66	67	70 r/	70
Total	97,500 r/	93,800 r/	93,600 r/	91,700 r/	91,600

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 22, 1995.

3/ Reported figure.

4/ May include nitrogen content of urea.

5/ Dissolved Dec. 31, 1992.

6/ Data are for years beginning Apr. 1 of that stated.

7/ Dissolved in Dec. 1991.

8/ Synthetic anhydrous ammonia; excludes coke oven byproduct ammonia.

9/ Dissolved in Apr. 1992.

PEAT

By Raymond L. Cantrell

Peat is a renewable, natural organic material of botanical origin and commercial significance that is deposited over more than 4% of the Earth's surface, where it plays an active role in the dynamics of our planet's ecosystem. Commercial peatlands are situated predominately in shallow wetlands areas of the northern hemisphere, where large deposits developed from the gradual decomposition of plant matter under anaerobic, or oxygen free, conditions.

Peat has widespread use as a plant growth medium in a variety of horticultural and agricultural applications, where its fibrous structure and porosity promote a unique combination of water retention and drainage characteristics, along with an affinity for plant available mineral nutrients. Commercial applications include potting soils, lawn and garden soil amendments, and turf maintenance on golf courses. In industry, peat is used primarily as a filtration medium to remove toxic materials from mine and process waste streams, pathogens from sewage effluents, and deleterious materials suspended in municipal storm drain water. In its dehydrated form, peat becomes hydrophobic, and is a highly effective absorbent for fuel and oil spills, on both land and water.

In 1994, the United States continued as a significant producer and consumer of peat for horticultural, agricultural, and industrial purposes. A variety of peat types was extracted and processed from over 70 identified operations in 20 of the lower 48 States, and Alaska, including reed-sedge, sphagnum moss, humus, and hypnum moss, in order of importance. Approximately 85% of U.S. peat production was from the Southeast, and Great Lakes States, where Florida, Michigan, and Minnesota ranked as the dominant producers. The United States imported about 55% of its total domestic peat requirements, principally from Canada, where there were extensive deposits of sphagnum peat moss. A small amount of peat was exported. *(See figure 1.)*

U.S. peat production and sales continued to be in a long term downward spiral, according to data reported to the U.S. Bureau of Mines (USBM) by domestic producers. Record high imports of Canadian sphagnum retained apparent domestic consumption at a relatively flat 1.2 million metric tons. The U.S. peat industry has been adversely impacted by stringent wetlands legislation at the Federal and State levels in recent years, that has hampered the permitting of new bogs for replacement or expansion. Several producers were integrating compost into their product lines to absorb a wealth of renewable organic material generated by the nation's efforts to recycle yard waste.

Production

Peat production in the United States decreased 7% between 1993 and 1994, according to the USBM annual survey of domestic peat producers. This was in line with a long-term trend of declining U.S. peat production, a concomitant drop in the number of domestic operations, relatively flat domestic consumption, overall, and the capture of an increasing market share by Canadian sphagnum peat moss producers shipping to the United States. *(See table 1.)*

Geographically, domestic production was dominated by several operations in the Great Lakes region, and the Southeast, where Florida, Michigan, and Minnesota were the dominant producers, in order of importance, according to information reported to the USBM by the industry. Approximately 20% of U.S. production was from operations in the Midwest, Northeast, and western States. Large operations—23,000 tons and above—accounted for more than 65% of total U.S. production. Reed-sedge peat accounted for about 70% of domestic production by weight; sphagnum moss, 15%; humus, 9%; and hypnum moss, 6%. *(See tables 2, 3, and 4.)*

Consumption

Domestic peat sales volume in 1994 trended downwards and amounted to 552,000 tons, or 45% of total U.S. apparent domestic consumption. Packaged materials were about 54% of total domestic sales tonnage and commanded premium prices. Canadian imports reached a record high 645,000 tons, and accounted for 54% of total U.S. apparent domestic consumption. Ireland and several other countries, principally in Scandinavia, shipped minor tonnages that accounted for less than 1% of total U.S. peat demand. A small drop in domestic inventories accounted for the remainder. Domestic peat sales, by weight, followed the same relative distribution trend as production, led by reed-sedge, humus, sphagnum moss, and hypnum moss, in order of importance. High quality sphagnum peat moss ranked second to reed-sedge on a volume basis, however, because of its high fiber and low density characteristics. Thus, reed-sedge sales were about 70% of the total, by volume; sphagnum moss, 18%; humus, 7%; and hypnum moss, 5%.

Approximately 95% of domestic peat was sold for use in general soil improvement, potting soils, earthworm culture, the nursery business, and golf course maintenance and construction, in order of importance. The remainder was used in a variety of applications, including seed inoculants, vegetable cultivation, mixed fertilizers, packing for flowers and plants, and in the industrial sector. Worcester Peat of Cherryfield, Maine, operated the only peat fired electrical power/plant in the United States. *(See tables 3, 5, and 6.)*

Stocks

U.S. peat stocks fell by a moderate 6%, to about 250,000 tons in 1994. Reed-sedge peat was 68% of the total; sphagnum, 15%; humus, 10%; with hypnum moss and other forms accounting for the remainder. *(See table 4.)*

Prices

The total f.o.b. plant value of domestic peat sold in the United States in 1994 was $15.3 million, according to the USBM annual survey of domestic peat producers. Although the total value of domestic peat fell relative to 1993, owing to a decline in sales volume, the average unit value was up slightly to $27.70 per ton, compared with $27.50 in 1993. The total wholesale value of the U.S. peat supply in 1994, including imported material, amounted to more than $141 million, compared with about $135 million in 1993.

Reed-sedge peat was valued at $8.7 million, f.o.b. plant, and accounted for 57% of total domestic product sales value; followed by sphagnum moss, $4.5 million, 29%; humus, $1.3 million, 8%; and hypnum moss, $0.9 million, or 6% of total. On a unit value basis, packaged sphagnum moss was valued at near $100 per ton, f.o.b plant; hypnum moss, $65 per ton; humus, $22 per ton; and, reed-sedge, $17 per ton. *(See tables 1, 3, 5, 7, and 8.)*

Foreign Trade

The United States continued to export minor tonnages of peat, which amounted to 23,000 tons in 1994. U.S. peat was valued at $2.2 million, or about $95 per ton, free-along-side-ship (f.a.s.). U.S. peat exports were principally to Latin American countries. *(See table 8.)*

Canadian sphagnum moss import volume reached a record high of 665,000 tons in 1994, and carried a customs value of $126 million, or $189 per ton. This was $6 per ton, or 3% higher than the comparable unit value in 1993. Imports from Ireland were 600 tons, and carried a customs value of $76,000 or $127 per ton. Ireland's Shamrock Peat brand was selected as the material of choice for greens reconstruction at the Atlanta Athletic Club golf course in Georgia. Seven countries, including Denmark, Finland and Norway in Scandinavia; Germany and the Netherlands in Western Europe; together with New Zealand and Sri Lanka; shipped 3,500 tons that carried a customs value of $509,000 or $146 per ton.

World Review

Twenty-two countries were known to produce peat in 1994, according to information available to the USBM. Countries in the former U.S.S.R. were estimated to account for about 84% of global peat production, although a continuing decline was believed to have occurred owing to political restructuring and unfavorable economic trends. Russia, the Ukraine, and Belarus were the leading producers in the former U.S.S.R., in order of importance. The Baltic Republics of Estonia, Latvia, and Lithuania also produced significant quantities of peat.

Peat production outside the former U.S.S.R. was dominated by Finland, Ireland, Germany, Sweden, and Canada, in order of importance, which, in combination, accounted for 15% of global production. The remainder was produced principally by the United States, with minor contributions from countries in Africa, Eastern Europe, Latin America, Western Europe, and Oceania. *(See table 9.)*

Canada.—Natural Resources Canada reported that Canadian peat production reached a new record high of 1.1 million tons in 1994. New Brunswick was the principal factor, where production was up 65% to 465,000 tons. Total Canadian peat shipments were estimated at 952,000 tons valued at $138 million. The eastern provinces of New Brunswick and Quebec accounted for 60% of the total, while Alberta and Manitoba, in western and central Canada, respectively, shipped another 33%. The remainder was supplied from Newfoundland, Nova Scotia, and Saskatchewan. Canada consumed about 19% of total shipments and exported the remainder.[1]

China.—The first international peat conference ever organized in China under the auspices of the International Peat Society (IPS)—"Wetland Environment and Peatland Utilization"—was held August 9-11, 1994, in the northeastern city of Changchun. The historic peat conference was organized by the Changchun Institute of Geography of the Chinese Academy of Sciences, and was cosponsored by Wuhan Institute of Survey and Geophysics and supported by the National Natural Science Foundation of China and Changchun Branch of the Chinese Academy of Sciences.

According to the Director of the Changchun Institute of Geography, there are 25 million hectares (ha) of wetlands in China. The mires cover roughly 11 million ha, of which the share of geological peatlands is over 4 million ha. There has been a long history of peatland use for the cultivation of rice, vegetables, and cotton. Other information revealed that there were a total of 37 peat production sites in China, which include 7 billion tons of peat, principally in Jilin and Heilonjiang Provinces. In Heilonjiang Province, there is a joint Chinese-American company producing horticultural peat for Far Eastern markets.[2]

Former U.S.S.R.—The Russian National Committee of the IPS reported that as of January 1991, explored and forecast peat reserves in Russia comprised 161.2 billion tons of conventional air dried peat (40% moisture), and were concentrated at 46,119 peat deposits comprising an area of about 46.3 million ha. In 1975, 135 million tons was reported to have been extracted, followed by increasing quantities. In 1992, after the dissolution of the U.S.S.R., production was reported to have declined to 61.2 million tons, of which about 88% was for horticultural/agricultural use, and 12% for fuel use.

Large specialized enterprises of the Russian Fuel Association extracted all fuel peat and peat for processing and about 16% of agricultural peat. Agricultural peat was extracted, for the most part, on various small sites belonging to nonindustrial organizations. The trend, however, is toward extraction by larger, more specialized industrial peat enterprises.[3]

Current Research and Technology

Researchers at the Natural Resources Research Institute (NRRI), University of Minnesota at Duluth, were studying the growth and regeneration of sphagnum top moss. NRRI reported that top moss is a renewable resource, and may be harvested in 5-10 year rotations. In Wisconsin, sphagnum top moss is harvested for commercial use in hanging baskets, wreaths, seed germination, and as a packing material. NRRI research demonstrated that top moss also shows potential as an effective oil sorbent, and that Minnesota has the potential to participate in a variety of top moss markets if successful regeneration can be accomplished.[4]

U.S. Bureau of Mines research personnel at Salt Lake City, UT, continued to report the successful commercial introduction of its patented Bio-Fix Bead peat technology. The technology was being commercialized at the Asarco Globe Facility in Denver, CO, a facility that refines a variety of metals.

Hazardous mine waste effluent streams and other industrial waste streams containing cadmium, copper, lead and zinc have been effectively treated. Because of the peat bead's affinity for metal ions at very low concentrations, treated effluents frequently meet National Drinking Water Standards and other discharge criteria.[5]

Outlook

The outlook for horticulture and associated businesses is bright, because global demand for various plants, flowers, ornamental trees, natural turf, and outdoor recreational activities continues to grow at impressive rates. The U.S. Department of Agriculture anticipates that the growth in monetary value for this industry in the United States will outpace that of traditional agriculture throughout the remainder of the decade. The outlook for the domestic peat industry, therefore, will likely be governed by several variables, including future wetlands environmental regulation, the ability to permit new bogs, growth and competition from recycled yard wastes and other natural organic materials, Canadian competition, and the degree of market penetration by flowers and ornamentals from offshore.

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[1] Bergeron, M. Peat 1994. Natural Resources Canada (Ottawa, Ontario), 1994, 10 pp.

[2] International Peat Society Bulletin 25, 1994, Jyvaskyla, Finland, pp. 41-54.

[3] Work cited in footnote 1, pp. 55-58.

[4] NRRI Now. Top Moss Shows Commercial Potential. Nat. Resour. Res. Inst., Univ. of MN, Duluth, winter, 1995, p. 6.

[5] Jeffers, T. H., and A. E. Isaacson. Peat Moss in Plastic Beads: New Waste Water Treatment. AMC Journal, Nov. 1994, pp. 5-8.

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TABLE 1
SALIENT PEAT STATISTICS 1/

		1990	1991	1992	1993	1994
United States:						
Number of active producers		82	76	71	67	70
Production	thousand metric tons	692	632	599	616	574
Sales by producers	do.	721	703	652	612	552
Bulk	do.	360	348	288	343	255
Package	do.	361	355	365	268	297
Value of sales	thousands	$19,200	$17,800	$16,700	$16,800	$15,300
Average per metric ton		$26.63	$25.29	$25.68	$27.54	$27.22
Average per metric ton, bulk		$19.58	$20.22	$19.31	$19.62	$18.70
Average per metric ton, package or baled		$33.65	$30.26	$30.71	$37.67	$26.44
Exports	thousand metric tons	12	13	22	8	23
Imports for consumption	do.	543	573	639	648	669
Consumption, apparent 2/	do.	1,230	1,250	1,230	1,290	1,240
Stocks, December 31: Producers'	do.	357	298	308	269	252
World: Production	do.	180,000	165,000	155,000 r/	144,000 r/	139,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Apparent consumption equals U.S. primary production plus imports minus exports plus adjustments for industry stock changes.

TABLE 2
RELATIVE SIZE OF PEAT OPERATIONS IN THE UNITED STATES

Size in metric tons per year	Active operations		Production (thousand metric tons)	
	1993	1994	1993	1994
23,000 and over	8	9	363	380
14,000 to 22,999	6	2	92	37
9,000 to 13,999	5	4	57	45
5,000 to 8,999	8	11	53	71
2,000 to 4,999	13	10	38	28
1,000 to 1,999	6	9	7	10
Under 1,000	21	25	7	4
Total 1/	67	70	616	574

1/ Data may not add to totals shown because of independent rounding.

TABLE 3
U.S. PEAT PRODUCTION AND SALES BY PRODUCERS IN 1994, BY STATE 1/

Region and State	Active operations	Production	Sales		
		Quantity (thousand metric tons)	Quantity (thousand metric tons)	Value 2/ (thousands)	Percent packaged
Northeast					
Pennsylvania	7	11	11	$296	10
Other 3/	8	63	26	1,270	XX
Total	15	74	37	1,560	XX
Great Lakes					
Michigan	8	156	156	5,090	92
Minnesota	9	37	37	3,010	34
Other 4/	15	57	63	1,360	XX
Total	32	250	256	9,470	XX
Southeast					
Florida	9	214	206	3,230	18
Other 5/	2	24	24	574	XX
Total	11	238	230	3,810	XX
West					
Washington	4	3	3	111	--
Other 6/	8	8	26	389	XX
Total	12	11	29	500	XX
Total or average	70	574	552	15,300	54

XX Not applicable.

1/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add totals shown.

2/ Values for f.o.b. producing plant.

3/ Includes Maine, Massachusetts, New Jersey, New York, and West Virginia.

4/ Includes Illinois, Indiana, Ohio, and Wisconsin.

5/ Includes North Carolina, and South Carolina.

6/ Includes Colorado, Iowa, Montana, and North Dakota.

TABLE 4
U.S. PEAT PRODUCTION AND PRODUCERS' YEAREND STOCKS IN 1994, BY KIND 1/

Kind	Active operations	Production (metric tons)	Percent of production	Yearend stocks (metric tons)
Sphagnum moss	14	87,800	15	37,900
Hypnum moss	10	31,400	6	2,540
Reed-sedge	35	392,000	68	173,000
Humus	15	51,400	9	25,500
Other	2	11,400	2	12,400
Total	70 2/	574,000	100	252,000

1/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Number of active operations include plants producing multiple kinds of peat.

TABLE 5
U.S. PEAT SALES BY PRODUCERS IN 1994, BY TYPE AND USE 1/

Use	Sphagnum moss			Hypnum moss			Reed-sedge		
	Quantity		Value	Quantity		Value	Quantity		Value
	Weight (metric tons)	Volume 2/ (cubic yards)	(thou-sands)	Weight (metric tons)	Volume (cubic yards)	(thou-sands)	Weight (metric tons)	Volume (cubic yards)	(thou-sands)
Earthworm culture medium	44	78	$1	--	--	--	47,500	105,000	$723
General soil improvement	32,600	168,000	3,530	8,950	22,900	$528	208,000	497,000	4,920
Golf courses	3,630	20,000	266	1,450	3,200	43	7,940	22,100	315
Ingredient for potting soils	181	500	6	14,000	31,800	219	144,000	304,000	2,180
Mixed fertilizers	--	--	--	567	1,250	31	--	--	--
Nurseries	9,790	50,300	609	1,350	5,000	53	16,300	40,400	444
Packing flowers, plants shrubs, etc.	185	1,700	62	45	100	1	181	500	6
Seed inoculant	--	--	--	--	--	--	4,540	10,000	88
Vegetable growing	--	--	--	340	750	5	--	--	--
Other	503	1,310	15	--	--	--	--	--	--
Total	46,900	242,000	4,490	26,700	65,000	881	429,000	978,000	8,680

Use	Humus			Other			Total		
	Quantity		Value	Quantity		Value	Quantity		Value
	Weight (metric tons)	Volume (cubic yards)	(thou-sands)	Weight (metric tons)	Volume (cubic yards)	(thou-sands)	Weight (metric tons)	Volume (cubic yards)	(thou-sands)
Earthworm culture medium	916	1,950	$18	--	--	--	48,500	107,000	$742
General soil improvement	36,100	67,700	1,010	12	25	(3/)	286,000	755,000	9,990
Golf courses	1,410	2,810	24	--	--	--	14,400	48,100	648
Ingredient for potting soils	5,540	11,100	77	--	--	--	164,000	348,000	2,480
Mixed fertilizers	--	--	--	--	--	--	567	1,250	31
Nurseries	2,610	5,300	79	--	--	--	30,100	101,000	1,180
Packing flowers, plants shrubs, etc.	272	500	3	--	--	--	684	2,800	71
Seed inoculant	--	--	--	--	--	--	4,540	10,000	88
Vegetable growing	771	1,500	17	12	25	(3/)	1,120	2,280	22
Other	1,870	3,530	55	--	--	--	2,380	4,840	71
Total	49,500	94,400	1,280	24	50	$1	552,000	1,380,000	15,300

1/ 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Volume of nearly all sphagnum moss was measured after compaction and packaging.

3/ Less than 1/2 unit.

TABLE 6
AVERAGE DENSITY OF DOMESTIC PEAT SOLD IN 1994 1/

(Kilograms per cubic meter)

	Sphag-num moss	Hypnum moss	Reed-sedge	Humus	Other
Bulk	284	558	593	665	617
Package	239	475	555	694	--
Bulk and package	254	537	573	688	617

1/ To convert kilograms per cubic meter to pounds per cubic yard multiply by 1.685.

TABLE 7
PRICES 1/ FOR PEAT IN 1994

(Dollars per unit)

	Sphag-num moss	Hypnum moss	Reed-sedge	Humus	Other	Average
Domestic:						
Bulk:						
Per metric ton	47.48	16.78	16.32	19.21	26.73	18.70
Per cubic yard	12.53	8.69	9.02	11.82	15.32	9.60
Packaged or baled:						
Per metric ton	97.99	64.49	16.94	22.23	--	26.44
Per cubic yard	21.70	28.44	8.74	14.36	--	12.29
Average:						
Per metric ton	78.81	27.16	16.65	21.36	26.73	27.22
Per cubic yard	18.59	13.55	8.87	13.60	15.32	11.11
Imported, total, per metric ton 2/	XX	XX	XX	XX	XX	171.31

XX Not applicable.

1/ Prices are f.o.b. plant.

2/ Average customs value.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF PEAT MOSS, 1/ 2/ BY COUNTRY

Country	1993		1994	
	Quantity (metric tons)	Value 3/ (thousands)	Quantity (metric tons)	Value 3/ (thousands)
Canada	645,000	$118,000	665,000	$126,000
Ireland	875	127	600	76
Other 4/	2,350	406	3,490	509
Total	648,000	118,000	669,000	126,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Poultry and fertilizer grade.

3/ Customs value.

4/ Includes Denmark, Finland, Germany, Netherlands, New Zealand, Norway, and Sri Lanka.

Source: Bureau of the Census.

TABLE 9
PEAT: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina: Agricultural use	7 r/	1 r/	1 r/	11 r/	11
Australia e/ 4/	11	11	11	11	15
Belarus: e/					
Agricultural use	XX	XX	10,000	10,000	10,000
Fuel use	XX	XX	4,000 r/	4,000 r/	6,000
Burundi	12	10	12	10 e/	10
Canada: Agricultural use	716	856	740	801 r/	1,020 5/
Denmark: Agricultural use (sales)	225 6/	184 r/	195	189 r/	190
Estonia: e/					
Agricultural use	XX	XX	5,000	4,500	4,500
Fuel use	XX	XX	600	600	1,000
Finland:					
Agricultural use	330 e/	220	355	350 r/ e/	550 5/
Fuel use	4,500 e/	2,310	5,100	5,000 r/ e/	8,000
France: Agricultural use e/	200	200	200	200	200
Germany: Western states: 7/					
Agricultural use	2,980	2,880	2,720	2,740 r/	2,800
Fuel use	238	225 e/	188	180 r/	180
Hungary: Agricultural use e/	65	65	65	65	65
Ireland:					
Agricultural use	229	249	300 e/	300 e/	250
Fuel use	6,430	4,770	6,200	6,500 e/	6,400
Latvia: e/					
Agricultural use	XX	XX	5,000	4,500	4,500
Fuel use	XX	XX	300	300	500
Lithuania: e/					
Agricultural use	XX	XX	5,000	4,500	4,500
Fuel use	XX	XX	100	100	200
Netherlands e/	300	300	300	300	300
Norway: e/					
Agricultural use	30	30	30	30	30
Fuel use	1	1	1	1	1
Poland: Agricultural and fuel use e/	50	50	50	50	50
Russia: e/					
Agricultural use	XX	XX	80,000	70,000	60,000
Fuel use	XX	XX	5,000	5,000	4,000
Spain e/	77	75	70	70	70
Sweden: e/					
Agricultural use	250 5/	263 5/	260	250 e/	250
Fuel use	1,400	1,400	1,400	1,400	1,400
Ukraine: e/					
Agricultural use	XX	XX	20,000	20,000	20,000
Fuel use	XX	XX	1,000	1,000	1,000
U.S.S.R.: 8/					
Agricultural use e/	150,000	140,000	XX	XX	XX
Fuel use	11,200	10,000	XX	XX	XX
United States:					
Agricultural use	692	632	599	616	547 5/
Fuel use	W	W	W	W	W
Total fuel use	23,800	18,700 r/	23,900 r/	24,100 r/	28,700
Grand total	180,000	165,000	155,000 r/	144,000 r/	139,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 20, 1995.

3/ In addition to the countries listed, Austria, Iceland, and Italy produce negligible amounts of fuel peat. The Eastern states of Germany and Venezuela are major producers, but output is not officially reported, and available information is inadequate for formulation of estimates of output levels.

4/ Excludes data from some states.

5/ Reported figure.

6/ Reported production figure.

7/ Production in eastern states has historically been confidential; no basis exists for reliable estimation.

8/ Dissolved in Dec. 1991.

PERLITE

By Wallace P. Bolen

Consolidations, new operations, and record production and consumption made 1994 a remarkable year for the perlite industry. A record-setting 644,000 metric tons shattered the previous high for processed perlite sold or used from U.S. mines in a single year. The previous record of 599,000 tons was set in 1979. Records for the amount and value of expanded perlite sold or used in the United States also set corresponding records. *(See table 1.)*

Production

U.S. production of processed perlite increased 13% in quantity and 11% in value according to the United States Bureau of Mines (USBM). Expanded perlite, sold or used by domestic producers, increased 13% in quantity, to 636,000 metric tons, and the associated value increased 11% compared with 1993. Construction uses of expanded perlite, mostly formed products, accounted for over 71% of total domestic sales in 1994.

Domestic production data for perlite are developed by the USBM from two voluntary annual surveys, one for domestic mine operations and the other for expanding plants. All of the processed perlite in table 1 was produced by eight mines operated by six companies in 1994. All the mining operations fully responded to the survey request, a 100% response rate. Three companies reported three mines idle, bringing the total to eight companies with active or inactive perlite mines. Of the 69 expanding plants canvassed, 64 were active; 62 plants, or 90% responded, representing nearly 99% of the total expanded perlite sold or used shown in table 1. The perlite mined came from four Western States with New Mexico operations accounting for the vast majority of the total tonnage mined. The remaining tonnage came from Arizona, California, and Nevada. Ore producers were Harborlite Corp. in Arizona and New Mexico; American Perlite Co. in California; Wilkins Mining and Trucking Co. and Eagle-Picher Minerals Inc. in Nevada; and Dicaperl Corp. and USG Corp. in New Mexico.

On March 2, 1994, GAF Corp., Wayne, New Jersey, purchased International Permalite Company's Ontario, California, and Florence, Kentucky, expanding plants. GAF, a diversified company involved with broadcasting, building materials, and chemicals, intends to expand perlite mainly for roof insulation board manufacture.

Harborlite Corp. continued its acquistion activities as they purchased the two expanding facilities of Filter Media, Inc., March 24, 1994. The expanding plants that produced mainly filter aid were located near Reserve, Louisiana, and LaPorte, Texas. Both operations will be renamed as Harborlite Corp. Harborlite now operates seven expanding plants and two mines.

Celotex Corp. purchased Apache Building Materials Company's Meridian, Mississippi, expanding plant in December 1994. Coupled with its plant in L'Anse, Michigan, Celotex is now the seventh largest expander of perlite in the United States. The top seven producers of expanded perlite, each with production over 30,000 tons annually, accounted for 83% of expanded perlite sold or used in the United States in 1994. The remaining 17% was sold or used by 28 companies.

Consumption

Domestic apparent consumption is defined as U.S. processed perlite sold and used plus imports minus exports. Domestic apparent consumption of processed perlite in 1994 was 684 metric tons, an increase of 13% from that of 1993. Consumption of expanded perlite for construction-related uses, the major market for expanded material, increased 18% to 454,000 tons. Expanded perlite used as filter aid, fillers, and in agricultural markets totaled 168,000 tons, about the same as in 1993. Leading States, in descending order of expanded perlite sold and used, were Georgia, Mississippi, Illinois, Pennsylvania, Alabama, California, Florida, and Virginia. *(See tables 2 and 3.)*

Prices

Processed perlite sold at an average value of $29.94 per ton. Perlite consumed by expanding plants operated by the mining companies was valued by the mining companies at $30.18 per ton. The average price for all perlite sold or used by mining companies was $30.03 per ton. The average price of expanded perlite was $194 per ton but there was a wide range in quoted prices from less than $100 to over $1,000 per ton.

The average prices for a ton of expanded perlite, by use in descending order, were low-temperature insulation, $494; fillers, $356; cavity-fill insulation, $325; horticultural aggregate, $298; concrete aggregate, $280; filter aid, $272; high-temperature insulation, $249; oil and water absorbent, $245; plaster aggregate, $198; miscellaneous uses, $184; acoustic tile, $152; and roof insulation board, $132.

Foreign Trade

Perlite exports, primarily to Canada, were estimated to be 30,000 tons. Imports of perlite ore, mainly from Greece, were about 70,000 tons, about the same as in 1993.

World Review

The United States was estimated to be the largest producer and consumer of perlite, both crude and expanded. Other leading countries, in descending order of production of processed (unexpanded) perlite, were Turkey, Greece, and Japan. Thirteen countries contributed a total of 1.58 million tons of processed perlite. However, this total does not include several producing countries due to a lack of reliable figures. *(See table 4.)*

Outlook

Unless there is change in what has been a generally robust construction market, perlite sales are expected to see modest growth in 1995. It was anticipated that the non-construction markets for perlite will see smaller but still positive growth.

TABLE 1
MINED, PROCESSED, EXPANDED, AND SOLD AND USED BY PRODUCERS IN THE UNITED STATES 1/

(Thousand metric tons and thousand dollars)

Year	Perlite mined 2/	Processed perlite					Expanded perlite		
		Sold to expanders		Used at own plant to make expanded material		Total quantity sold and used 3/	Quantity produced	Sold and used	
		Quantity	Value	Quantity	Value			Quantity	Value
1990	659	391	11,100	185	6,340	576	484	478	90,600
1991	711	421	12,100	93	2,940	514	459	449	102,000
1992	762	422	11,700	118	3,490	541	551	550	113,000
1993	691	453	13,800	116	3,680	569	566	562	111 000
1994	664	531	15,900	114	3,440	644	636	636	123,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Crude ore mined and stockpiled for processing.

3/ Data may not add to totals shown because of independent rounding.

TABLE 2
EXPANDED PERLITE PRODUCED AND SOLD AND USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

State	1993				1994			
	Quantity produced (metric tons)	Sold and used			Quantity produced (metric tons)	Sold and used		
		Quantity (metric tons)	Value (thousands)	Average value per ton 2/		Quantity (metric tons)	Value (thousands)	Average value per ton 2/
California	43,900	43,800	$9,590	$220	42,700	42,900	$10,400	$242
Florida	36,800	36,400	8,310	228	39,300	38,700	9,120	235
Mississippi	64,900	64,900	7,540	116	74,800	74,800	7,280	100
Pennsylvania	58,500	58,500	10,100	173	46,900	46,900	8,610	184
Texas	20,600	19,100	6,850	359	16,300	16,300	4,670	286
Other 3/	341,000	339,000	68,200	201	416,000	416,000	83,400	200
Total	566,000	562,000	111,000	197	636,000	636,000	123,000	194

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Average value based on unrounded data and rounded to nearest dollar.

3/ Includes Alabama, Arizona, Arkansas (1993), Colorado, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Missouri, Nevada, New Jersey, (1993), North Carolina, Ohio, Oklahoma, Oregon, Tennessee, Utah, Virginia, Wisconsin, and Wyoming.

TABLE 3
EXPANDED PERLITE SOLD AND USED BY PRODUCERS IN THE UNITED STATES, BY USE
(Metric tons)

Use	1993	1994
Concrete aggregate	8,420	4,610
Fillers	45,300	43,500
Filter aid	70,000	69,600
Formed products 2/	360,000	432,000
Horticultural aggregate 3/	52,600	55,100
Low-temperature insulation	4,670	2,730
Masonry and cavity-fill insulation	9,930	10,200
Plaster aggregate	5,940	6,840
Other4/	5,100	11,500
Total	562,000	636,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significent digits; may not add to totals shown.

2/ Includes acoustic ceiling tile, pipe insulation, roof insulation board, and unspecified formed products.

3/ Includes fertilizer carriers.

4/ Includes high-temperature insulation, oil-water absorbents, acoustic tile, paint extender (1994) and various nospecified industrial uses.

TABLE 4
PERLITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Armenia 4/	XX	XX	50000 e/	10,000 e/	5,000
Australia e/ 5/	5,000	5,000	5,000	5,000	5,000
Czechoslovakia e/ 6/ 7/	54,000 8/	50,000	50,000	XX	XX
Greece (screened) e/	240,000	286,000 8/	250,000	250,000	200,000
Hungary 5/	93,000	87,800	93,000 e/	90,000 e/	95,000
Iran	2,270	6,280	5,000	6,000 e/	6,000
Italy e/	71,000	70,000	65,000	65,000	65,000
Japan e/	203,000	203,000	203,000	200,000	200,000
Mexico 5/	42,400	48,900	42,600	34,600 r/	35,000
Philippines	3,150	2,890	2,800 e/	19,800 r/	20,000
Slovakia 7/	XX	XX	XX	50,000 e/	50,000
South Africa, Republic of	200	41	97	328 r/	300
Turkey 5/	139,000	88,000	281,000	213,000 r/	250,000
U.S.S.R. e/ 4/ 9/	150,000	80,000	XX	XX	XX
United States (processed ore sold and used by producers)	576,000	514,000	541,000	569,000	644,000 8/
Total	1,580,000	1,440,000	1,590,000 r/	1,510,000 r/	1,580,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2 /Unless otherwise stated, figures represent processed ore output. Table contains data available through May 26,1995.

3/ In addition to the countries listed, Algeria, Bulgaria, China, Iceland, Mozambique, and the former Yugoslavia are believed to have produced perlite, but output data are not reported, and available information is inadequate for the formulation of reliable estimates of output levels.

4/ All production in the U.S.S.R. from 1990-91 came from Armenia.

5/ Crude ore.

6/ Dissolved on Dec. 31, 1992.

7/ All production in Czechoslovakia from 1990-92 came from Slovakia.

8/ Reported figure.

9/ Dissolved in Dec. 1991.

PHOSPHATE ROCK

By Raymond L. Cantrell

Phosphate rock mineral deposits are the only significant global resource of phosphorus, a chemical element essential to plant and animal life. The United States is the world's leading producer and consumer of phosphate rock, which is used to manufacture phosphate fertilizers and industrial products for domestic use and export. Florida and North Carolina produce about 85% of the marketable phosphate rock mined in the United States, and process most of the refined mineral in cost effective fertilizer upgrading facilities that are situated to be highly competitive in the global marketplace.

Phosphate rock also is produced in the western States of Idaho and Utah where the mineral is upgraded into high analysis phosphate fertilizers and elemental phosphorus (P_4), which is used to produce downstream industrial products. Phosphate rock supplies from Idaho and Utah are used as inputs to facilities that provide fertilizer to consuming States in a vast region extending from the Midwest to the Pacific Coast and into Canada. The States of Idaho and Montana produce essentially all of the P_4 consumed domestically and exported from the United States.

In 1994, marketable phosphate rock production and consumption in the United States increased markedly because of record diammonium phosphate (DAP) export shipments to China and rising domestic fertilizer demand which was created by a substantial increase in planted feedgrain acreage. Economic recovery led to an additional increase in the production of phosphate rock for a variety of industrial products manufactured principally from P_4, and purified wet-process phosphoric acid. Most mines and finished phosphate materials plants that were temporarily idled during 1993, because of a down cycle in the U.S. phosphate sector, returned to production.

U.S. phosphate rock sold or used by producers was 44 million metric tons, equating to 88% of effective industry capacity, and accounting for more than 30% of total global deliveries. Wet-process phosphoric acid (WPPA) production was 11.2 million tons as available phosphorus pentoxide (P_2O_5), which represented an industry operating rate of nearly 100%. Heavy demand for downstream phosphate fertilizer products produced from WPPA was reflected by rising prices for downstream phosphate fertilizer products as the year progressed. The United States accounted for more than 50% of global interregional converted phosphate P_2O_5 trade in 1994, led by ammonium phosphates—DAP and monoammonium phosphate (MAP)—granular triple superphosphate (GTSP), and WPPA, in order of importance. Value-added byproducts from WPPA manufacture, principally hydrofluosilicic acid for water fluoridation, and uranium oxide yellow cake for electrical power generation continued to be recovered by the industry.

Many positive factors, which provide for an optimistic outlook through the turn of the century, can be traced to major industry consolidation and restructuring in Florida and the western States during the past few years. A protracted period of global phosphate fertilizer oversupply, grain surpluses, and depressed prices between 1981 and 1986 dictated that the U.S. industry should consolidate and incorporate advanced technologies in the WPPA manufacturing process, including wet rock grinding, and the cogeneration of electrical power from byproduct steam. The net result was that by 1994, a few major firms, operating under vastly improved economies of scale, dominated the industry. Added benefits were more effective vertical integration between phosphate rock mining, finished phosphate manufacture, and marketing. *(See tables 1 and 2.)*

Legislation and Government Programs

Section 313 of the Enviromental Protection Agency's Emergency Planning and Community Right-to-Know Act of the Superfund Amendments and Reauthorization Act (SARA) of 1986 (Public Law 99-499) required EPA to establish a national inventory of toxic chemical emissions from certain facilities, called the Toxics Release Inventory (TRI). EPA's 1992 TRI published in April 1994, indicated that phosphoric acid emissions of 94,000 tons ranked fourth among the 1.4 million tons released by the top 50 TRI chemicals, and accounted for about 7% of the total. This amount was only about 0.5% of total U.S. WPPA production.[1]

On December 8, 1994, the U.S. President signed the Uruguay Round GATT Agreements Act, H.R. 5110, which was designated as Public Law No. 103-465. This action resulted from several years of global trade negotiations that began in Uruguay, designed to liberalize trade under the auspices of the longstanding General Agreement on Tariffs and Trade (GATT). The new GATT agreement was expected to gradually result in the lowering of tariff barriers, thus improving the prospects for improved access of U.S. agricultural exports to major countries around the globe.[2]

Production

The U.S. Bureau of Mines, Department of the Interior, conducted semiannual Mineral Industry Surveys of all identifiable U.S. phosphate rock producers, to provide the public and private sectors with information and analysis on the situation and outlook for this essential, finite mineral resource.

Florida.—In central Florida, phosphate rock was mined and processed by five producers in Polk, Hillsborough, and Hardee Counties: Cargill Fertilizer, Inc.; CF Industries, Inc.; IMC-Agrico Co., a joint-venture partnership between IMC Fertilizer Group, Inc. and Freeport-McMoRan Resource Partners L.P.; Mobil Mining and Minerals Corp.; and, U.S. Agri-Chemicals Corp., owned by the Chinese subsidiary Sinochem (USA) Inc. Nu-Gulf Industries 1.5-million-ton-per-year Wingate Creek Mine and the associated Mulberry Phosphates, Inc., Piney Point ammonium phosphate conversion plant in Manatee County, FL, were idle.

In northeast Florida, Occidental Chemical

Corp. (OxyChem) produced phosphate rock from the 3.5-million-ton-per-year Swift Creek Mine, primarily for upgrading into granular ammonium phosphate fertilizers. OxyChem's 2.3-million-ton-per-year Suwannee River Mine continued to be closed for economic factors associated with the loss of a large superphosphoric acid (SPA) trade contract with the former U.S.S.R. Recoverable phosphate rock reserves at yearend were estimated at about 65 million tons averaging 66.4% bone phosphate of lime (BPL).[3]

Cargill Fertilizer, Inc. operated the 3-million-ton-per-year Fort Meade beneficiation plant in Polk County based on ore mined from its Carlton tract in Hardee County. The firm also operated the Hookers Prairie Mine, a 2.5-million-ton-per-year operation in Polk County. Marketable phosphate rock from Fort Meade was shipped to Cargill's Tampa Bay, FL, plant where 700,000 tons per year P_2O_5 WPPA, ammonium phosphates, and GTSP fertilizers were produced. The Hookers Prairie Mine supplied Cargill's large WPPA and granular ammonium phosphate facility at Bartow, FL. Current reserves, together with planned acquisitions, should allow Cargill to continue mining phosphate rock in Florida well into the 21st century.[4]

CF Industries announced plans to commission its new 3.2-million-ton-per-year South Pasture Mine in Hardee County in the fall of 1995. The project had an authorized budget of $175 million. In 1994, CF ran a large, 900,000-ton-per-year P_2O_5, WPPA plant and granular ammonium phosphate complex at Plant City, FL, based on phosphate rock purchased domestically. The new mine should provide CF with enough captive phosphate rock tonnage to sustain operations at Plant City for at least another 20 years. Reserves at South Pasture were about 90 million tons as recoverable product.[5]

IMC-Agrico Co. operated seven mines in 1994 having an aggregate annual capacity of about 30 million tons, representing about 55% of total U.S. capacity. Active operations included the Four Corners Mine on the Hillsborough-Manatee County line; the Fort Green and Payne Creek Mines in Polk-Hardee Counties; the Kingsford Mine in Polk-Hillsborough Counties; the Hopewell Mine, in Hillsborough County; together with Noralyn-Phosphoria in Polk County. The firm's Clear Springs Mine in Polk County also was operational. Effective June 30, 1994, IMC-Agrico reported title to an estimated 325 million tons of recoverable phosphate rock reserves in central Florida, averaging 68% BPL.

In June, IMC-Agrico purchased the Fort Lonesome and Haynesworth Mines in Hillsborough and Polk Counties that had been leased from Brewster Phosphates. The aggregate annual capacity of the idle mines was about 5 million tons, according to IMC Fertilizer Group reports.

U.S. Agri-Chemicals' joint-venture Rockland Mine with Freeport-McMoRan in Polk County was closed during the first-half of 1994 following the formation of IMC-Agrico. IMC-Agrico assumed control of the remaining reserves at Rockland and entered into a long-term tolling agreement extending through the year 2004 to supply marketable phosphate rock for Agri-Chemicals' 450,000 ton-per-year P_2O_5 WPPA conversion facility at Fort Meade, FL.

In July 1994, IMC-Agrico entered into an optional agreement with Mississippi Chemical Corp. of Yazoo City, MS, to purchase the remaining reserves on a 4,860 hectare (ha)—12,000 acre—contiguous tract in Hardee County. containing an estimated 80 million tons of phosphate rock reserves. IMC-Agrico reported title and options to a total of approximately 0.5 billion tons of recoverable phosphate rock reserves in Hardee, Manatee, and DeSoto Counties. averaging 65% BPL—described as the South Florida deposits.

IMC-Agrico's annual WPPA production capacity in Florida and Louisiana was about 4 million tons P_2O_5, which represented approximately 32% of total U.S. capacity and 11% of global capacity. WPPA and associated downstream conversion plants were operating at New Wales, Nichols, and South Pierce in Polk County; and, at Faustina and Uncle Sam, LA, along the Mississippi River. The firm shipped WPPA to its Taft, LA, plant for upgrading into granular ammonium phosphates, and produced animal feed-grade phosphate supplements at New Wales, FL, for Mallinckrodt Veterinary, Inc. Uranium oxide was extracted from WPPA produced at the Faustina and Uncle Sam, LA, facilities, while uranium recovery facilities at New Wales and Plant City, FL, were idle in 1994. The firm exported phosphate raw materials and finished products through the Phosphate Rock Export Association (PhosRock) and Phosphate Chemicals Export Association (PhosChem), formed under provisions of the Webb-Pomerene Act with other U.S. producers.[6]

Mobil was building a new mine at South Fort Meade in southeastern Polk County, FL., with a planned annual capacity of 3.5 million tons. The new mine was projected to be capable of sustaining annual design productivity over the next 25 years. The firm planned to close its Big Four Mine in Hillsborough, County, following depletion in mid-1995, and was to place the Nichols Mine in Polk County on standby. In addition to phosphate rock sales on the domestic and export markets, Mobil produced WPPA and ammonium phosphates in a whollyowned conversion facility at Pasadena, TX.[7]

Farmland Industries, Inc.-Norsk Hydro, L.P., and Mulberry Phosphates, operated WPPA and ammonium phosphate plants at Green Bay and Bartow, FL, respectively, based on phosphate rock purchased domestically.

North Carolina.—Texasgulf Chemicals Co., a division of Texasgulf, Inc., operated a large mine and processing plant along the Pamlico River in Beaufort County, NC, near the towns of Aurora and Washington. The mine and beneficiation plants had the capability to produce flotation-grade, calcined-grade, and direct application-grade phosphate rock for domestic use and export. Phosphate rock reserves on three contiguous tracts were estimated at about 1 billion tons, recoverable, according to Texasgulf technical personnel.

Texasgulf produced up to 1.2 million tons P_2O_5 WPPA annually in a chemical complex adjacent to the mine; additional downstream products: SPA, DAP, MAP, liquid ammonium phosphates, GTSP, and calcium phosphate animal feed supplements also were produced at the site. Animal feed phosphate supplements, including defluorinated phosphate rock (DFP), also were produced offsite. Texasgulf operated a purified WPPA industrial grade plant on-site in cooperation with Albright and Wilson, Ltd. of the United Kingdom. Texasgulf was owned principally by Elf Aquitaine S.A. of France, while the Williams Companies, Inc. of the United States held a minority interest.

Western States.—In Idaho, five firms mined or processed phosphate rock, either for the production of P_4 in electric furnaces for industrial applications, or for conversion to WPPA and finished phosphate fertilizers. In Utah, Simplot-Farmland (SF) Phosphates Ltd. Co.—a joint venture between J. R. Simplot and Farmland Industries, Inc.—operated a major mining and phosphate rock benefication facility at Vernal, UT, used for phosphate fertilizer production at Rock Springs, WY. Cominco Fertilizers, Inc's. Warm Springs underground mine at Garrison, MT, was closed, but small quantities of direct application phosphate rock continued to be shipped from inventories.

Idaho.—Three producers conducted open pit mining from the Phosphoria Formation in Caribou County, ID, producing phosphate rock of about 60% BPL average as feedstock for P_4 furnaces. FMC Corp. operated the Dry Valley Mine on federal and private leases to provide feedstock for P_4 production at Pocatello, ID. The Monsanto Co. produced phosphate rock from the Enoch Valley Mine in the Caribou National Forest for P_4 production at Soda Springs, ID. Rhone-Poulenc Basic Chemicals Co. produced phosphate rock from the Rasmussen Ridge Mine in the Caribou National Forest for P_4 manufacture at Silver Bow, MT, and domestic sales. In 1994, total U.S elemental phosphorus production, in aggregate, was about 230,000 tons P_4, according to the U.S. Department of Commerce, Bureau of the Census.

J. R. Simplot produced beneficiated phosphate rock for fertilizer manufacture from the Smoky Canyon Mine in the Caribou National Forest. Marketable product was pumped through a 140 kilometer (km)—87 mile—buried slurry pipeline to Simplot's fertilizer conversion facility at Pocatello. The conversion facility was capable of producing about 400,000 tons P_2O_5 as WPPA annually for downstream SPA, ammonium phosphates, GTSP, and calcium phosphate animal feed-grade product. Ammonia, urea-ammonium nitrate (UAN) solutions, ammonium sulfate, and nitric acid also were produced.

Nu-West Industries, Inc. produced phosphate rock ore from the firm's Mountain Fuel Mine on Dry Ridge through November 1993. In March 1994, Rhone-Poulenc began supplying phosphate rock ore to Nu-West under the terms of a 7-year contract negotiated in November 1993. Rhone-Poulenc was to supply about 1.5 million tons of phosphate ore annually to Nu-West for processing, and upgrading to WPPA, SPA, and ammonium phosphates at Conda, ID. Nu-West reported proven reserves approximating 60 to 70 million tons primarily on leased Federal and State lands. A plan to mine an estimated 6 million tons of phosphate ore from its North Mabie Canyon Extension lease was approved by government agencies. Effective July 1994, all assets of the whollyowned Conda Partnership—formerly a joint venture with Western Cooperative Fertilizers (United States)—were transferred to Nu-West Mining or Nu-West Industries, and the Conda Partnership was dissolved. Nu-West also announced that it was exploring alternatives for enhancing long-term business prospects, including joint ventures with other fertilizer producers, the sale or merger of the firm, or a continuation of the current internal growth strategy.[8]

Utah.—SF Phosphates produced flotation concentrate from its Vernal, UT, mine, and pumped the material over the Uinta Mountains through a 155 km—96 mile—buried slurry pipeline to a whollyowned conversion plant at Rock Springs, WY. SF's Rock Springs facility produced WPPA, SPA and granular ammonium phosphate fertilizer. Surplus phosphate rock capacity and substantial reserves at Vernal resulted in long-range plans to significantly expand the Rock Springs conversion facility.

Consumption

In 1994, U.S. apparent domestic consumption of phosphate rock increased 13% compared with 1993. About 90% of the total was consumed in the manufacture of 11.2 million tons P_2O_5 WPPA for downstream fertilizer, animal feed derivatives, and purified WPPA for industrial applications. The balance was used to produce P_4 for industrial applications, including detergent and food additives, water and metal treatment chemicals, plasticizers, pesticides, vitamins, soft drinks, toothpaste, film, light bulbs, bone china, flame-resistant fabrics, optical glass, and other consumer goods.*(See tables 3, 4, and 5.)*

Domestic phosphate fertilizer consumption rose 2% to 4.1 million tons P_2O_5, between 1993 and 1994, accounting for about 37% of the total U.S. WPPA supply. The remainder was principally for exports of upgraded phosphate products.

Stocks

Phosphate rock stocks continued the downward trend established in 1993. At yearend, stocks were averaging about 2-month's production equivalent. This was in line with cost effective initiatives adopted by major producers in the industry. *(See table 1.)*

Transportation

In Florida, beneficiated phosphate rock was moved by rail and truck to finished phosphate upgrading facilities. Phosphate rock and finished phosphate materials were railed to ports at Tampa and Jacksonville, FL, for export or domestic use. Finished phosphate fertilizers and phosphate rock were barged up the Mississippi River and other major tributaries for domestic consumption and were also transported inland by rail and truck.

In North Carolina, Texasgulf barged phosphate rock and finished products to the port at Morehead City for export and domestic shipment. Rail facilities also were utilized extensively for transport.

Western producers moved phosphate rock from mines to plants by rail, truck, and slurry pipeline. Finished product was moved predominately by rail and truck.

Prices

In 1994, marketable phosphate rock was valued at $20.42 per-metric-ton, f.o.b. mine, a decline of about 4.5% from that of 1993. Gross revenues, however, were up by more than 5% owing to heavier volume. Industry consolidation and restructuring resulted in improved operating efficiencies and lower raw materials costs. The price of domestic phosphate rock was more reflective of producer cost because of a higher degree of vertical integration between captive phosphate rock production and upgraded phosphate manufacture. *(See tables 6, 7, and 8.)*

Foreign Trade

U.S. phosphate rock exports continued to trend downwards between 1993 and 1994, falling 13%. Geographically, about 54% of U.S. phosphate rock export shipments were to the Far East—principally, the Republic of Korea and Japan—Western Europe, 24%; Oceania, 11%; Canada, 8%; and Latin America, 3%.

Closures of WPPA plants in Western Europe and Canada, political restructuring in Eastern Europe, together with the popularity of value-added converted phosphate products in international trade, in combination have resulted in a major decline in global phosphate rock trade in recent years. This, in turn, has intensified competitive forces between major offshore phosphate rock producing countries for dwindling raw materials markets and placed downward pressure on U.S. exporters. Additionally, U.S. phosphate rock shipments in North America—Canada and Mexico—have been largely displaced by Togo and Morocco, respectively.

Arcadian Corp. and Mississippi Phosphates Corp. opted to import Moroccan phosphate rock used in phosphate conversion plants at Geismar, LA, on the Mississippi River, and at Pascagoula, MS, on the U.S. Gulf Coast. Arcadian also operated a purified WPPA industrial grade plant at Geismar on behalf of Rhone-Poulenc Chemical Co. The Moroccan Office Cherifien des Phosphates (OCP) reported phosphate rock shipments of 1.8 million tons to the United States in 1994, compared with 900,000 tons in 1993.

U.S. converted phosphate trade volume and unit value were up substantially in all major categories compared with 1993, led by record DAP shipments to China. The United States continued to dominate world interregional converted phosphate trade in 1994, accounting for about 53% of the 10.4 million ton P_2O_5 total, according to data reported by the International Fertilizer Industry Association (IFA), Paris, France. U.S. DAP export shipments were 74% of the global total; MAP, 94%; GTSP, 39%; and merchant-grade WPPA, 14%. *(See tables 8, 9, 10, 11, 12, 13, 14, and 15.)*

World Review

World phosphate rock production was about 129 million tons in 1994, an increase of more than 7% compared with 1993, according to data received from IFA subsequent to the preparation of table 17. Phosphate rock shipments for domestic conversion and export rose 6% to a level of 135 million tons, which reflected a drawdown of inventories and improved demand for finished phosphate products and raw materials at the global level. Home deliveries for conversion into upgraded phosphate materials for domestic consumption and export accounted for about 80% of the total, with phosphate rock exports making up the remainder. WPPA plants in the major export oriented countries of the United States, Morocco, Tunisia, Senegal, South Africa, and Jordan, were pressured to meet demand, and operated at between 90% to 100% of rated capacity in 1994, according to IFA.

The United States continued to lead global phosphate rock output, accounting for about 32% of total production and 33% of total shipments, respectively. About 65% of the total increase in world phosphate rock production and shipments between 1993 and 1994 was attributable to rising domestic and international demand for upgraded U.S. phosphate materials. IFA data for 1994 indicated that production and shipments were also up in the important African countries and in the Middle East. In Socialist Asia, phosphate rock production continued to be dominated by China, with an estimated output of 26 million tons, or 20% of the world total; Vietnamese production at the new Lao Cay Mine expansion was up 40% to 500,000 tons.

Africa.—**Egypt.**—Egypt's ongoing project to develop a 2-million-ton-per-year mine at Abu Tartur in the Western Desert was further delayed owing to technical problems and an incomplete railway link of 350 km between Abu Tartur and Quena in the Nile Valley; the railway between Safaga on the Red Sea coast and Quena, however, was complete. Only the pilot beneficiation plant was operating at this high temperature underground mine. Consequently, the Sebaya East Mine in the Nile Valley will remain open and continue to produce single superphosphate (SSP). The high iron sulfide content of Abu Tartur phosphate rock inhibits efficient filtration in WPPA manufacture, according to World Bank sources.

Morocco.—A major capacity expansion was planned in Morocco, where OCP was to bring another eight, 165,000-ton-per-year P_2O_5 WPPA units on-stream at Jorf Lasfar, doubling capacity at the facility around the turn of the century. Additional ammonium phosphate and GTSP capacity was also to be built.

During 1994, Morocco had an approximate 20% phosphate rock capacity surplus, i.e., output about 5 million tons below annual production capability of about 25 million tons. In the major mining center at Khouribga, phosphate extraction was to gradually shift from the depleting Sidi Daoui reserves to a large new open pit mine at Sidi Chennane. At Youssoufia, white rock reserves were depleting and being replaced by black rock mined underground and upgraded by calcining. Two mines at Ben Guerir provided lower grade phosphate rock for domestic conversion. Bou Craa in the Western Sahara was producing about 1.2 million tons of high grade 80% BPL material for export.

Senegal.—An approximate two-fold expansion of WPPA capacity to 640,000 tons per year P_2O_5 was planned by the turn of the century. At this time, the Keur Mor Fall deposit should deplete and a new mine would be commissioned at Tobene. Phosphate rock exports were to be largely displaced by upgraded product.

South Africa.—Indian Ocean Fertilizer planned to debottleneck its Richards Bay WPPA plant to a rated capacity of 500,000 tons per year P_2O_5 by 1996. Foskor beneficiated phosphate-bearing tailings from ore mined by the Palabora Mining Company Ltd. (PMC), and produced high grade phosphate rock assaying 80% BPL and above for domestic conversion and export, at Phalaborwa.

Asia.—In China, a total of 1 million annual tons P_2O_5 as WPPA was scheduled to come on-stream in seven provinces, primarily during 1996 and 1997. IFA analysts, however, did not believe that China's huge volume of upgraded phosphate imports would be significantly affected owing to the large imbalance in the fertilizer ratio between nitrogen and phosphate, favoring nitrogen. There were also interesting developments in China's phosphate rock supply-demand situation in 1994. Chinese imports ceased altogether, while high grade domestic phosphate rock was present in an increasing number of export markets, including India, Korea, Malaysia, and the Philippines. China's export grade phosphate rock was believed to be from Yunnan province, and was transported over long distances to the ports.

Former U.S.S.R.—Phosphate rock

production—principally on the Kola Peninsula in Russia, and at Karatau in Kazakhstan—decreased about 30% between 1993 and 1994, and was down 50% compared with 1992. The region continued to be plagued by rising production costs, inadequate electrical power supplies for elemental phosphorus furnaces in Kazakhstan, logistical problems, and declining domestic phosphate demand.

Latin America.—In 1994, the Peruvian Sechura Desert phosphate rock deposit at Bayovar in the northwestern coastal region was placed in the hands of CEPRI BAYOVAR, a special committee formed to promote outside equity participation through the privatization of the State-owned mining enterprise, GRAU BAYOVAR. Presently, 80,000 to 100,000 tons per year of marketable rock is produced, 80% for single superphosphate production (20% P_2O_5), and the remainder for direct application exports to New Zealand.

Phosphate rock reserves in the two main areas explored total about 380 million tons as 66% BPL concentrate. Beneficiation may be effected by a simple process involving washing and floating with seawater, followed by rinsing with freshwater. A mine and beneficiation plant to produce 2 million tons concentrate annually was envisioned, which would include some production of direct application rock. Additionally, conversion plants to produce WPPA and DAP were being considered. The reserves are 30 km from the Pacific Ocean near Bayovar Bay, where a loading dock would be constructed. Large fresh water aquifers and adequate electrical power was available in the vicinity. Countries in the Pacific Basin and South America were considered to hold strategic market potential. Peru's more favorable economic and political climate have improved the probability for project fruition by the turn of the century.[9]

Middle East.—**Israel.**—Rotem Fertilizer planned to commission a new 300,000-ton-per-year P_2O_5 WPPA plant at Mishor Rotem in the second half of 1996. Negev Phosphates mined phosphate rock at Arad, Oron and Nahal Zin, with a combined annual capacity of about 5.5 million tons.

Jordan.—Jordan Phosphate Mines (JPMC) had new projects underway at Aqaba and near the new mining operation at Es Shidiya. At Aqaba, JPMC planned to complete a debottlenecking project designed to raise WPPA capacity 10% to 450,000 tons per year P_2O_5 by 1996, while an 80,000-ton-per-year P_2O_5 joint venture with Nippon of Japan was under construction and scheduled operational in 1997. In addition, a 200,000-ton-per-year P_2O_5 joint venture WPPA project was planned with Fauji Fertilizer of Pakistan (FFC) for completion in 1997 or 1998. This material was to be exported to supply the FFC-JPMC joint venture DAP facility planned at Port Qasim near Karachi, Pakistan.

At Es Shidiya, a 200,000-ton-per-year P_2O_5 WPPA joint-venture project between JPMC and India's Southern Petrochemical Industries Corp. (SPIC)—Indo Jordan Chemicals —was under construction and scheduled operational in 1997. WPPA will be shipped to SPIC's phosphate fertilizer plant at Tuticorin, Tamil Nadu in southern India. JPMC planned to gradually expand the new 3-million-ton-per-year mine at Es Shidiya, given its logistical advantages to the port at Aqaba over existing mines at El Hassa and El Abiad in central Jordan.

Saudi Arabia.—Applications were solicited from established companies with mining and processing experience to prequalify for the exploitation of the Al Jalamid Phosphate rock deposit, 120 km from the town of Turayf in northern Saudi Arabia near the border of Iraq. The proposed $1.7 billion project was to include an open pit mine and beneficiation plant with an annual production capacity of 4.5 million tons of high quality 71% BPL phosphate rock, a slurry pipeline for the transport of flotation concentrate to Al Jubail on the Persian Gulf, and, an attendant 2.9- million-ton-per-year DAP fertilizer facility.

A feasibility study was completed for the Directorate General of Mineral Resources (DGMR) by Jacobs International, Inc. under the direction of the U.S. Geological Survey (USGS). The study indicated that the Al Jalamid deposit contained proven reserves of 213 million tons of crude ore averaging 46% BPL. In view of the size, costs and technical difficulties, the project will probably not be fully implemented until after the turn of the century.

Oceania.—Sulfur dioxide pollution abatement measures from smelters in Queensland, Australia, dictated that an imminent decision be made to promote a phosphate project based on acidulated phosphate rock from the idle Duchess phosphate rock mine, near Mount Isa.

Western Europe.—The tight phosphate supply-demand situation in 1994 resulted in a 42% increase in Spanish WPPA production, and a decision to operate the last French WPPA plant originally slated for closure in 1996, beyond the turn of the century.

Current Research and Technology

The Florida Institute of Phosphate Research (FIPR) in Bartow, FL, was actively engaged in funding about $3 million for several autonomous and contract projects involving chemical processing, mining and beneficiation, reclamation, and environmental services. FIPR's priority projects in order of importance were phosphogypsum, reclamation, public health, industry efficiency, and waste clay ponds. U.S. Patent No. 5262064—Dewatering Instantaneously with Pulp Recycle—was issued to FIPR on November 16, 1993. FIPR's 1993-94 Annual Report indicated that the process was useful for rapidly consolidating phosphatic waste clays. An interested party signed a licensing agreement designed to potentially utilize the process to remove and consolidate organic muck from a fresh water lake.

In the chemical processing area, FIPR contracted Jacobs Engineering of Lakeland, FL, to explore ways of significantly reducing the quantity of phosphogypsum produced in WPPA manufacture by removing some or all of the free calcite and dolomite from ground rock feed for a WPPA plant, by flotation. The obvious advantages would be a lowering of sulfuric acid consumption per ton of P_2O_5 produced, lower carbon dioxide production and a concomitant decrease in defoamer usage, together with higher throughput. Related projects involving phosphogypsum were centered about more efficient filtration and recovery of phosphate values in WPPA production and environmental remediation.

The U.S. Bureau of Mines Research Center at Tuscaloosa, AL, received additional FIPR funding for an ongoing project designed to delineate the migration of metal and nonmetal ions through active and inactive commercial phosphogypsum stacks. The Research Center was to initiate a new project in the fall of 1994—The Characterization and Utilization of Phosphate Processing Wastes (FIPR 93-01-

108R)—designed to demonstrate that previous findings of uniform liquid ionic movement through phosphogypsum stacks may lead to the possible removal of all water soluble elements from a closed phosphogypsum stack by the natural leaching action of rainwater. The recovery of low pH acidic rainwater leachate effluent from the stack would serve to neutralize the stack and possibly prevent the costly necessity of "capping" inactive stacks.

Outlook

Regional supply-demand balances presented at the IFA Annual Conference in Singapore during May 1995 indicated that global phosphate rock supplies would be adequate during the 5-year forecast period 1995-99, with the surplus gradually declining from 15% of supply capability in 1995 to 12% by 1999. Global phosphate rock supply capability was forecast to increase about 7% or 11 million tons during the period, principally to cover new converted phosphate capacity additions. In the United States, surplus phosphate rock availability was expected to be maintained at 6 to 8 million tons per year (12% to 15% of supply capability on average) throughout the remainder of the decade.

The global WPPA P_2O_5 outlook was less certain, however, given variables in the projected outlook for supply capability in the former U.S.S.R. For example, the global P_2O_5 surplus availability narrowed from 6% of supply capability (1.5 million tons) in 1995 to an extremely tight 1% (300,000 tons) by 1999, under the assumption that operating capability in the former U.S.S.R. would not improve beyond the current 38%. Conversely, if operating capability in the former U.S.S.R. were to gradually improve to 65% of capacity by 1999, the global surplus availability could increase to 7% of supply capability (2.0 million tons P_2O_5). It is likely that the region would be required to import phosphate rock under this high-side scenario.

There were relatively small increases in net surplus WPPA P_2O_5 supply availability forecast for the principal exporting regions of Africa, the Middle East and North America—The United States and Canada—between 1995 and 1999. In North America, the WPPA P_2O_5 surplus availability was projected to remain constant at about 5.3 million tons, as the change in demand was approximately equal to that of supply. In the United States, there was no new WPPA capacity forecast on-stream through 1999 except for minor debottlenecking and the possible startup of an idle plant in Florida. There is an outside possibility that major expansions could be partially implemented in North Carolina and out West during the forecast period.

The major P_2O_5 deficit regions were Asia, Western Europe, Latin America, and Oceania, in order of importance.

Current WPPA P_2O_5 balances, while encouraging, also demonstrate the risks associated with implementing new capital intensive phosphate projects, and the prudence on the part of major exporting countries and financial institutions of proceeding with cautious optimism. The industry, however, will undoubtedly face major technological challenges to mine and process adequate supplies of finite phosphate rock resources needed to satisfy global demand for food and fiber during the 21st century.

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TABLE 1
SALIENT PHOSPHATE ROCK STATISTICS 1/

(Thousand metric tons and thousand dollars unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Mine production (crude ore)	151,000	154,000	155,000	107,000	157,000
Marketable production	46,300	48,100	47,000	35,500	41,100
P2O5 content	14,200	14,500	14,100	10,800	12,100
Value 2/	$1,080,000	$1,110,000	$1,060,000	$759,000	$839,000
Average per metric ton 3/	$23.20	$23.06	$22.53	$21.38	$20.42
Sold or used by producers 4/	49,800	44,700	45,100	40,100	44,100
P2O5 content	15,100	13,500	13,500	11,900	13,100
Value 2/	$1,150,000	$1,030,000	$1,020,000	$856,000	$901,000
Average per metric ton 3/ 5/	$23.20	$23.06	$22.53	$21.38	$20.42
Exports 6/	6,240	5,080	3,720	3,200	2,800
P2O5 content	2,020	1,640	1,200	1,020	886
Value 2/	$191,000	$163,000	$120,000	$91,200	$71,700
Average per metric ton 3/	$30.66	$32.00	$32.29	$28.51	$25.60
Imports for consumption	451	552	1,530	534 7/	620 7/
C.i.f. value	$21,900	$28,000	$56,200	$32,300	$30,200
Average per metric ton 8/	$48.57	$50.73	$36.71	$60.45	$48.76
Consumption 9/	44,000	40,200	42,900	38,300	43,100 e/
Stocks, Dec. 31: Producers	8,910	10,200	12,600	9,220	5,980
World: Production	162,000	150,000 r/	141,000 r/	121,000 r/	124,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ The total value is based on a weighted value.

3/ Computer-calculated average value based on the weighted sold or used values.

4/ Includes domestic sales and exports.

5/ Weighted average of sold or used values.

6/ Exports reported to the U.S. Bureau of Mines by companies.

7/ Some phosphate rock import tonnage and value were supressed by the Bureau of the Census.

8/ Average unit value obtained from unrounded data.

9/ Expressed as sold or used plus imports minus exports. Includes an estimated 900,000 tons of phosphate rock imported from Morocco not reported by the Bureau of the Census in 1993 and 1,800,000 tons in 1994.

TABLE 2
PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES, BY REGION 1/

(Thousand metric tons and thousand dollars)

Region	Mine production		Marketable production			
			Beneficiated			Stocks
	Rock	P2O5 content	Rock	P2O5 content	Value 2/	Rock
1993	107,000	18,400	35,500	10,800	759,000	9,220
1994:						
January-June:						
Florida and North Carolina	70,100	9,660	16,500	4,950	335,000	5,500
Idaho, Montana, and Utah	5,320	1,330	3,610	997	61,300	2,060
Total	75,400	11,000	20,100	5,950	396,000	7,560
July-December:						
Florida and North Carolina	76,600	11,500	17,500	5,240	385,000	3,940
Idaho, Montana, and Utah	4,620	1,150	3,450	965	58,300	2,040
Total	81,200	12,700	21,000	6,200	443,000	5,980
Grand total	157,000	23,700	41,100	12,100	839,000	XX

XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Computer-calculated value based on the weighted sold or used value.

TABLE 3
PHOSPHATE ROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES, 1/ BY GRADE AND REGION

(Thousand metric tons and thousand dollars)

Period and	Florida and North Carolina			Idaho, Montana, and Utah			Total		
Grade		P2O5			P2O5			P2O5	
(percent BPL 2/ content)	Rock	content	Value 3/	Rock	content	Value 3/	Rock	content	Value 3/
January-June 1993	17,000	5,130	378,000	2,900	813	49,700	19,900	5,940	428,000
July-December 1993	17,200	5,170	370,000	2,980	834	58,700	20,100	6,000	428,000
January-June 1994:									
72 to less than 74	890	299	24,100	434	146	16,200	1,320	445	40,300
70 to less than 72	147	48	4,300	--	--	--	147	48	4,300
66 to less than 70	13,900	4,250	245,000	436	137	8,190	14,400	4,390	253,000
60 to less than 66	3,760	1,050	105,000	596	166	5,790	4,360	1,210	111,000
Below 60	--	--	--	1,650	423	21,100	1,650	423	21,100
Total	18,700	5,650	379,000	3,110	872	51,300	21,800	6,520	430,000
July-December 1994:									
72 to less than 74	855	285	23,200	415	141	14,500	1,270	426	37,700
70 to less than 72	105	34	2,750	--	--	--	105	34	2,750
66 to less than 70	14,600	4,420	290,000	371	116	6,950	15,000	4,540	297,000
60 to less than 66	3,150	870	94,200	470	128	5,720	3,620	998	99,900
Below 60	--	--	--	2,310	604	33,200	2,310	604	33,200
Total	18,700	5,610	411,000	3,570	989	60,300	22,300	6,600	471,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ 1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P2O5.

3/ F.o.b. mine.

TABLE 4
PHOSPHATE ROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

(Thousand metric tons)

			1994					
	1993 total		January-June		July-December		Total	
Use	Rock	P2O5 content	Rock	P2O5 content	Rock	P2O5 content	Rock	P2O5 content
Domestic: 2/								
Wet-process phosphoric acid	32,400	9,720	18,700	5,600	19,600	5,830	38,300	11,400
Normal superphosphate	19	6	7	3	8	3	15	6
Triple superphosphate	193	64	4	1	26	8	30	9
Deflourinated rock	85	28	--	--	65	21	65	21
Direct applications	28	8	(3/)	(3/)	--	--	--	--
Elemental phosphorus	4,150	1,090	1,660	445	1,210	323	2,880	768
Ferrophosphorus	--	--	--	--	--	--	--	--
Total	36,900	10,900	20,300	6,050	21,000	6,180	41,300	12,200
Exports: 4/	3,200	1,020	1,480	469	1,320	417	2,800	886
Grand total	40,100	11,900	21,800	6,520	22,300	6,600	44,100	13,100

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes rock converted to products and exported.

3/ Less than 1/2 unit.

4/ Exports reported to the U.S. Bureau of Mines by companies.

TABLE 5
PHOSPHATE ROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE AND REGION 1/

(Thousand metric tons)

Period and Use	Florida and North Carolina Rock	Florida and North Carolina P2O5 content	Idaho, Montana, and Utah Rock	Idaho, Montana, and Utah P2O5 content	Total Rock	Total P2O5 content
1993	34,200	10,300	5,880	1,650	40,100	11,900
1994:						
January-June:						
Domestic: 2/						
Agricultural: 3/	17,200	5,170	870	283	18,100	5,460
Industrial	11	4	2,240	589	2,260	593
Subtotal	17,300	5,180	3,110	872	20,300	6,050
Exports: 4/	1,480	469	--	--	1,480	469
Total	18,700	5,650	3,110	872	21,800	6,520
July-December:						
Domestic: 2/						
Agricultural: 3/	17,300	5,160	1,980	550	19,300	5,710
Industrial	99	32	1,590	439	1,680	471
Subtotal	17,400	5,190	3,570	989	21,000	6,180
Exports: 4/	1,320	417	--	--	1,320	417
Total	18,700	5,610	3,570	989	22,300	6,600
Grand total	37,400	11,300	6,680	1,860	44,100	13,100

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes rock converted to products and exported.

3/ Primarily sales/use of wet-process phosphoric acid.

4/ Exports reported to the U.S. Bureau of Mines by companies.

TABLE 6
VALUE OF FLORIDA AND NORTH CAROLINA PHOSPHATE ROCK, BY GRADE

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL 1/ content)	1993 Domestic	1993 Export	1993 Average	1994 Domestic	1994 Export	1994 Average
74 or more	--	--	--	--	--	--
72 to less than 74	26.93	29.20	28.04	26.78	27.46	27.13
70 to less than 72	20.31	31.57	30.43	20.85	35.27	26.09
66 to less than 70	19.33	25.80	19.83	19.67	23.54	19.90
60 to less than 66	24.11	26.45	24.11	29.90	--	29.90
Less than 60	24.03	--	24.03	--	--	--
Weighted average	21.26	28.11	21.89	21.79	25.60	22.08

1/ 1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P2O5.

TABLE 7
VALUE OF IDAHO, MONTANA, AND UTAH PHOSPHATE ROCK, BY GRADE

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL 1/ content)	1993 Domestic	1993 Export	1993 Average	1994 Domestic	1994 Export	1994 Average
72 to less than 74	--	--	--	34.84	--	34.84
70 to less than 72	37.48	--	37.48	--	--	--
66 to less than 70	18.90	--	18.90	18.71	--	18.71
60 to less than 66	8.04	45.23	10.24	12.17	--	12.17
Less than 60	16.32	--	16.32	14.37	--	14.37
Weighted average	18.09	45.23	18.43	16.91	--	16.91

1/ 1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P2O5.

TABLE 8
VALUE OF U.S. PHOSPHATE ROCK, BY GRADE

(Dollars per metric ton, f.o.b. mine)

Grade	1993			1994		
(percent BPL 1/ content)	Domestic	Export	Average	Domestic	Export	Average
74 or more	--	--	--	34.84	--	34.84
72 to less than 74	30.51	29.20	30.00	30.79	27.46	29.65
70 to less than 72	34.51	31.57	32.73	20.85	35.27	26.09
66 to less than 70	19.31	25.80	19.79	19.18	23.54	19.87
60 to less than 66	22.48	45.02	22.62	27.60	--	27.60
Less than 60	17.91	--	17.91	14.37	--	14.37
Weighted average	20.76	28.51	21.38	20.89	25.18	21.14

1/ 1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P2O5.

TABLE 9
U.S. EXPORTS OF GROUND AND UNGROUND PHOSPHATE ROCK 1/ 2/

(Thousand metric tons)
(HTS Nos. 2510.10.0000 and 2510.20.0000)

Country	Quantity	
	1993	1994
Australia	188	183
Belgium	206	197
Brazil	20	30
Canada	263	309
France	14	(3/)
Germany	194	139
India	272	255
Japan	554	471
Korea, Republic of	1,050	1,010
Mexico	3	9
Netherlands	315	350
New Zealand	204	186
Romania	31	--
Other	254	171
Total	3,570	3,310

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Dollar values suppressed by the Bureau of the Census.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
U.S. EXPORTS OF SUPERPHOSPHATES 1/ 2/

(Thousand metric tons)
(HTS No. 3103.10.0020)

Country	Quantity	
	1993	1994
Argentina	14	14
Australia	228	225
Bangladesh	16	52
Brazil	99	209
Canada	53	25
Chile	148	151
Colombia	13	8
Costa Rica	2	2
Japan	50	31
Peru	14	6
Uruguay	4	5
Other	121	73
Total	762	801

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Dollar values suppressed by the Bureau of the Census.

Source: Bureau of the Census.

TABLE 11
U.S. EXPORTS
OF DIAMMONIUM PHOSPHATES 1/ 2/ 3/

(Thousand metric tons)
(HTS No. 3105.30.0000)

Country	Quantity	
	1993	1994
Argentina	190	205
Australia	436	415
Belgium	--	98
Brazil	77	134
Canada	175	78
Chile	108	53
China	2,110	5,410
Colombia	135	108
Costa Rica	10	11
Dominican Republic	33	45
Ecuador	38	22
France	34	49
Germany	91	123
Guatemala	5	12
India	1,190	435
Iran	32	190
Ireland	37	27
Italy	--	14
Japan	512	504
Kenya	62	78
Mexico	247	116
New Zealand	159	165
Pakistan	732	503
Peru	24	35
Spain	11	10
Thailand	87	68
Turkey	131	40
Uruguay	40	42
Venezuela	10	--
Other	652	205
Total	7,370	9,190

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Chemical analysis: Nitrogen (18%); P2O5 (46%).
3/ Dollar values suppressed by the Bureau of the Census.

Source: Bureau of the Census.

TABLE 12
U.S. EXPORTS OF
MONOAMMONIUM PHOSPHATE 1/ 2/ 3/

(Thousand metric tons)
(HTS No. 3105.40.0000)

Country	Quantity	
	1993	1994
Argentina	2	--
Australia	188	197
Brazil	132	301
Canada	395	417
Chile	34	58
China	2	--
Colombia	91	68
Costa Rica	20	26
Ecuador	5	2
Guatemala	22	8
Japan	111	131
Mexico	38	115
New Zealand	20	14
Peru	(4/)	5
Saudi Arabia	10	--
Thailand	(4/)	35
Uruguay	--	8
Venezuela	(4/)	(4/)
Other	23	93
Total	1,090	1,480

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Chemical analysis: Nitrogen (11%); P2O5 (52%).
3/ Dollar values suppressed by the Bureau of the Census.
4/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 13
U.S. EXPORTS OF
PHOSPHORIC ACID 1/2/3/

(Thousand metric tons)
(HTS No. 2809.20.0010)

Country	Quantity 1993	Quantity 1994
Australia	46	17
Canada	13	61
Colombia	6	9
India	138	190
Indonesia	61	18
Japan	(4/)	--
Venezuela	37	74
Other	197	147
Total	498	516

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Principally, "Merchant Grade" (54% - P2O5) product. Excludes superphosphoric acid tonnage reported under HTS No. 2809.20.0020, amounting to 101,000 tons in 1993 and 298,000 tons in 1994. The majority of these tonnages is believed to be Merchant phosphoric acid instead of superphosphoric acid.
3/ Dollar values suppressed by the Bureau of the Census.
4/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 14
U.S. EXPORTS OF ELEMENTAL PHOSPHORUS 1/

(HTS No. 2804.70.0000)

Country	1993 Quantity (Metric tons)	1993 Value 2/ (Thousands)	1994 Quantity (Metric tons)	1994 Value 2/ (Thousands)
Brazil	748	$1,500	663	$1,380
Canada	1,490	2,510	519	936
Japan	9,380	17,600	7,460	14,100
Korea, Republic of	24	101	54	82
Mexico	6,360	9,700	6,220	9,170
Netherlands	23	60	--	--
Other	333	691	320	688
Total	18,400	32,200	15,200	26,400

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits may not add to totlals shown.
2/ F.a.s. values.

Source: Bureau of the Census.

TABLE 15
U.S. IMPORTS FOR CONSUMPTION OF PHOSPHATE ROCK AND PHOSPHATIC MATERIALS 1/

(Thousand metric tons and thousand dollars)

Phosphatic materials	HTS No. 2/	1993		1994	
		Quantity	Value 3/	Quantity	Value 3/
Natural calcium 4/ phosphates unground	2510.10.0000	532	32,000	620	31,200
Natural calcium 4/ phosphates ground	2510.20.0000	2	251	1	215
Dicalcium phosphate	2835.25.0000	3	3,780	3	3,900
Phosphorus	2804.70.0000	1	7,260	1	3,020
Normal superphosphate	3103.10.0010	(5/)	(5/)	(5/)	28
Triple superphosphate	3103.10.0020	(5/)	8	44	8,150
Diammonium phosphate	3105.30.0000	38	7,100	15	4,270
Fertilizer containing nitrates and phosphates	3105.51.0000	56	5,600	189	21,100
Phosphoric acid	2809.20.0010	(5/)	12	1	376

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Harmonized tariff schedule of the United States.

3/ Declared c.i.f values.

4/ Excludes reported imports from Canada and Israel.

5/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 16
PHOSPHATE ROCK ANNUAL
WORLD PRODUCTION CAPACITY 1/ 2/
(DECEMBER 31, 1994)

(Thousand metric tons per year)

Region / country	Capacity	Percent
United States	51,000	31.0
Africa 3/	44,200	27.0
Socialist Asia 4/	27,200	16.0
Western Europe and the former U.S.S.R. 5/	20,900	13.0
Middle East 6/	13,900	8.0
Latin America 7/	5,300	3.0
South Asia 8/	1,600	1.0
Oceania 9/	1,300	1.0
World total	165,000	100.0

1/ Previously published data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes capacities of operating plants as well as plants on "Standby basis.

3/ Includes Algeria, Morocco, Senegal, The Republic of South Africa, Togo and others.

4/ Includes China, North Korea, Vietnam and others.

5/ Includes Finland, Kazakhstan, and Russia.

6/ Includes Egypt, Iraq, Israel, Jordan, Syria and others.

7/ Includes Brazil, Colombia, Mexico, Peru, Venezuela, and others.

8/ Includes India, Pakistan, and Sri Lanka.

9/ Includes Australia, Christmas Island, and Nauru.

Source: International Fertilizer Industry Association (IFA) and the U.S. Bureau of Mines (United States).

TABLE 17
PHOSPHATE ROCK, BASIC SLAG, AND GUANO: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

	Gross weight				
Commodity and country 3/	1990	1991	1992	1993	1994 e/
Phosphate rock:					
Albania e/	10	9	2	2	2
Algeria	1,130	1,090	1,140	718 r/	725
Australia	14 r/	2 r/	2 r/	2 r/	2
Brazil	2,970	3,280	2,850 r/	3,420 r/	3,400
Burkina Faso e/	-- r/	-- r/	-- r/	-- r/	--
Chile	15 r/	15 r/	18 r/	15 r/	15
China e/	21,600	22,000	23,000	24,000	24,000
Colombia	31	32	32	18 r/	20
Egypt	1,140	1,650	2,000	1,590 r/	1,500
Finland	546	472	555	628 r/	630
India	674	610 r/	488 r/	967 r/	900
Indonesia	2	6	8 e/	7 e/	7
Iraq e/ 5/	900	400	600 r/	800 r/	1,000
Israel 5/	3,520	3,370 e/	3,600	3,590 e/	3,600
Jordan	6,080	4,430	4,300	3,570 r/	3,500
Kazakhstan e/	XX	XX	7,000 r/	4,000 r/	3,000
Korea, North e/	500	500	500	510	510
Mali e/	10	--	--	--	--
Mexico 6/	623	596	515 /r	237 /r	533
Morocco 7/	21,400	17,900	19,100	18,300	18,000
Nauru	926	530	747	634 r/	613 8/
Netherlands Antilles e/	15	15	15	10	15
Pakistan	42 e/	19	20	14 r/	15
Peru e/	47 8/	30 r/	5 r/	5 r/	18
Philippines	3	21	5 r/	92 r/	20
Russia e/	XX	XX	11,500	9,400 r/	8,000
Senegal 9/	2,150	1,740	2,280	1,670 r/	1,600
South Africa, Republic of	3,170	3,180 r/	3,080 r/	2,470 r/	2,880
Sri Lanka	33	20	26	36 r/	35
Sweden	7	--	--	--	--
Syria	1,630	1,360	1,270	931 r/	900
Tanzania	25	22	22	22 e/	22
Thailand	10	6	8	11 r/	10
Togo	2,310	2,970	2,080 r/	1,750 r/	1,800
Tunisia	6,260	6,350	6,400	5,500 r/	5,500
Turkey	87	4	65	40 r/	80
Uganda	(4/)	(4/)	(4/)	(4/)	(4/)
U.S.S.R. e/ 10/	36,800	28,400	XX	XX	XX
United States	46,300	48,100	47,000	35,500	41,100 8/
Venezuela	165	162	10	-- r/	--
Vietnam	274	275 r/	290 r/	363 r/	375
Zimbabwe, concentrate	148	117	142	153 r/	160
Total	162,000	150,000 r/	141,000 r/	121,000 r/	124,000
Basic (Thomas converter) slag:					
Argentina e/	(4/)	(4/)	(4/)	(4/)	(4/)
Egypt e/	8	8	8	8	8
France	488	538	356	350 e/	300
Germany	128	142	120	100 e/	50
Luxembourg	603	536	519	555 r/ e/	500
Total	1,230	1,220	1,000	1,010 r/	858
Guano:					
Chile	2 r/	1	(4/)	--	--
Philippines	1	12	(4/) r/	5 r/	5
Total	3 r/	13	(4/) r/	5 r/	5

See footnotes at end of table.

TABLE 17—Continued
PHOSPHATE ROCK, BASIC SLAG, AND GUANO: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

	P2O5 Content				
Commodity and country 3/	1990	1991	1992	1993	1994 e/
Phosphate rock:					
Albania e/	1	1	(4/)	(4/)	(4/)
Algeria	333 e/	322 e/	340 e/	220 r/ e/	220
Australia	3 r/	(4/) r/	(4/) r/	(4/) r/	(4/)
Brazil	615 r/	650 r/	477 r/	605 r/	600
Burkina Faso e/	-- r/	-- r/	-- r/	-- r/	--
Chile	1 e/	1 e/	1 e/	1 e/	1
China e/	6,400	6,500	6,800	7,000	7,000
Colombia	8 e/	8 e/	5 r/ e/	5 r/ e/	8
Egypt	286 e/	413 e/	500 e/	390 r/ e/	390
Finland	201	170 e/	201	215 e/	215
India	181 r/ e/	168 r/	130 r/	259 r/	241
Indonesia	1	2 e/	2 r/ e/	2 e/	2
Iraq e/ 5/	270	120	180 r/	240 r/	300
Israel 5/	1,100 e/	1,070 e/	1,130 e/	1,120 e/	1,120
Jordan	2,010 e/	1,460 e/	1,410 e/	1,140 r/ e/	1,140
Kazakhstan e/	XX	XX	1,750 r/	1,000 r/	750
Korea, North e/	160	160	160	163	163
Mali e/	2	--	--	--	--
Mexico 6/	174 e/	180 /e	160 r/ e/	79 /r /e	178
Morocco 7/	6,910 e/	5,700 e/	6,180 e/	5,920 e/	5,900
Nauru	355 e/	204 r/	288 r/	244 r/	236 8/
Netherlands Antilles e/	5	5	5	3 r/	5
Pakistan	13 e/	6	6 e/	4 r/ e/	5
Peru e/	16	9 r/	2 r/	2 r/	6
Philippines	1 e/	7 r/ e/	2 r/ e/	31 r/ e/	7
Russia e/	XX	XX	4,000 r/	3,300 r/	2,800
Senegal 9/	777 e/	630 e/	830 e/	606 r/ e/	606
South Africa, Republic of	1,190 e/	1,210 r/ e/	1,170 r/ e/	969 r/ e/	1,130
Sri Lanka	11 e/	6 e/	6 e/	12 r/ e/	12
Sweden	3	--	--	--	--
Syria	511 e/	425 e/	395 e/	286 r/ e/	277
Tanzania	8 e/	7 e/	7 e/	7 e/	7
Thailand	3 e/	2	2	3 r/	3
Togo	840 e/	1,080 e/	760 e/	635 r/ e/	640
Tunisia	1,860 e/	1,880 e/	1,890 r/ e/	1,630 r/ e/	1,630
Turkey	27	1	20	12 r/	24
Uganda	(4/)	(4/)	(4/)	(4/)	(4/)
U.S.S.R. e/ 10/	11,800	9,250	XX	XX	XX
United States	14,200	14,500	14,100	10,800	12,100 8/
Venezuela	34	34 e/	3	-- r/	--
Vietnam	88 r/ e/	88 r/ e/	93 r/ e/	116 r/ e/	120
Zimbabwe, concentrate	52 e/	41 e/	42 e/	45 e/	45
Total	50,500 r/	46,300 r/	43,000 r/	37,100 r/	37,900
Basic (Thomas converter) slag:					
Argentina e/	(4/)	(4/)	(4/)	(4/)	(4/)
Egypt e/	2	2	2	2	2
France	88	97	64 r/	63 r/	54
Germany	19	21	18	15 e/	8
Luxembourg	109	95 e/	93 e/	100 r/ e/	75
Total	218	215	177 r/	180	139
Guano:					
Chile	(4/) e/	(4/) e/	(4/) e/	--	--
Philippines	(4/) e/	4 e/	(4/) r/ e/	2 r/ e/	2
Total	(4/)	4	(4/) r/	2 r/	2

e/ Estimated. r/ Revised. XX Not applicable.

1/ 1994 and previously published data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 5, 1995. Data for major phosphate rock-producing countries derived in part from the International Fertilizer Industry Association; other figures are from official country sources where available.

3/ In addition to the countries listed, Belgium may have produced small quantities of phosphate rock and Namibia may have produced small quantities of guano, but output is not officially reported, and available information is inadequate for formulation of reliable estimates of output levels.

4/ Less than 1/2 unit.

5/ Beneficiated.

6/ Includes only output used to manufacture fertilizers.

7/ Production from Western Sahara area is included.

8/ Reported figure.

9/ Does not include aluminum phosphate production, gross weight estimated as follows in thousand metric tons: 1990--127; 1991--92; 1992--75 1993--75; and 1994--75.

10/ Dissolved in Dec. 1991.

PLATINUM-GROUP METALS

By Robert G. Reese

Six metals, (platinum, palladium, rhodium, iridium, ruthenium, and osmium) make up the platinum group metals (PGM). Of the six metals, platinum and palladium are the most important commercially. PGM's are used as catalysts in the automotive, chemical, and petroleum industries. Other applications for the PGM's include the electrical and electronic, dental and medical, and jewelry industries.

Although generally found together, minable deposits of the PGM's are very rare. Often, PGM production occurs as a byproduct of some other metal, usually nickel or copper. Worldwide, the major PGM producing regions include the Republic of South Africa, Russia, Canada, the United States, and Colombia.

Identified world PGM resources at yearend 1994 were estimated at 100 million kilograms (kg). The reserve base was estimated at 66 million kg and reserves at 56 million kg. Of the reserve base and the reserves, the Republic of South Africa had nearly 90% of each; Russia had 9% and 11% respectively; and the United States had 1% and 0.4% respectively.

In the United States, the Stillwater Mine in Montana accounts for nearly all domestic PGM production. The remaining domestic PGM production occurs as a byproduct at some copper refining operations. Production at the Stillwater Mine consists primarily of palladium and platinum.

In 1994, the Stillwater Mining Co., operator of the Stillwater Mine, became a publicly traded and financed company. Of the original partners, Stillwater Mining redeemed Chevron Corp.'s 50% interest in the mine with proceeds from a private placement of common stock and notes. In December, Stillwater Mining closed its first public stock offering, and used a portion of the proceeds from this sale to redeem the notes issued in the earlier private placement.

At the same time as the public offering, Manville Corp., the mine's other founding partner, reduced its holding in Stillwater Mining from 50% to 27% through a secondary stock offering.

Production at the Stillwater Mine declined in 1994 despite increased ore production. In 1993, the Stillwater Mine produced nearly 2,050 kg of platinum and 6,780 kg of palladium, while in 1994, the mine produced 1,960 kg and nearly 6,440 kg of platinum and palladium, respectively.[1] Company officials attributed the lower production to lower ore grades mined in 1994. During the year, the company adopted a plan to increase ore production at Stillwater from 336,000 metric tons per year to more than 660,000 tons per year by mid-1997. As part of this plan, the company began construction of a new 530-meter shaft in October.

The Stillwater Mining Co. concentrates and smelts the ore from the Stillwater Mine locally. The resulting PGM-bearing matte is shipped to Belgium for refining. In the United States, secondary PGM's were refined by about 20 firms, mostly on the East and West coasts. PGM were sold by at least 90 processors and dealers, largely in the Northeast.

Historically, the U.S. Bureau of Mines developed data on industry held stocks, refinery production, and consumption of PGM's from a voluntary survey of domestic refiners. Continued low response rates by industry to the Bureau's canvass have resulted in a decision to not publish these data for 1994. Beginning in 1995, the Bureau will combine the three separate surveys for gold, silver, and PGM into a single annual survey of precious metal refiners. It is hoped that by reducing the burden for industry, the response rate will improve, and that publication of quality data can be resumed.

The average dealer price for platinum increased from $370 per ounce for 1993 to $401 per ounce for 1994. Similarly, the average dealer price for palladium increased from $120 for 1994 to $142 for 1993. For 1994, average dealer prices for the remaining PGM'S were iridium, $30; osmium, $400; rhodium, $717; and ruthenium, $12. In 1993, the average prices were $47, $400, $1,066, and $13 per ounce for iridium, osmium, rhodium, and ruthenium respectively.

Total accountable platinum stocks at yearend 1994 increased by 340 kg over those of yearend 1993. The increased holdings were in stocks held by futures exchanges, which at yearend 1994 were 3,860 kg of platinum. Stocks of palladium held by futures exchanges also increased, from 1,150 kg at yearend 1993 to 1,980 kg at yearend 1994. Other accountable stocks of PGM's include those held by the Federal Government in the National Defense Stockpile. These stocks remained unchanged from the previous year, and at yearend 1994 consisted of 14,100 kg of platinum, 39,300 kg of palladium, and 920 kg of iridium.

Outlook

Demand for PGM is expected to continue to grow worldwide, given the strong demand for a cleaner environment. Many countries already require the use of catalytic converters for controlling emissions from gasoline-powered automobiles, and other countries are expected to adopt these requirements. Although both platinum and palladium are used in catalytic converters, in the short-term, platinum is expected to remain the dominant metal, owing primarily to the need to use up to three times as much palladium to obtain the desired emissions reduction. Domestically, the demand for PGM is also expected to grow as increasingly stringent standards for automobile emissions are adopted.

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[1] Stillwater Mining Co. 1994 Annual Report, 56 pp.

TABLE 1
U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF PLATINUM GROUP METALS IN 1994 1/

(Kilograms)

Country	Ores and concentrates	Waste and scrap	Refined					
			Platinum	Palladium	Rhodium	Iridium	Osmium	Ruthenium
			Imports					
Australia	--	4	927	--	--	--	--	--
Belgium	--	10	1,850	10,200	150	--	--	--
Brazil	--	2	232	374	--	--	--	--
Canada	--	148	1,150	1,700	--	(2/)	--	(2/)
Chile	--	--	--	54	--	--	--	--
China	--	108	33	1,250	--	--	--	--
Colombia	--	2	2,430	--	--	--	--	--
Estonia	--	11	--	46	--	--	--	--
Finland	--	10	--	22	--	--	--	--
France	--	381	132	137	8	--	--	--
Germany	--	19	1,210	3,220	181	227	3	471
Hong Kong	--	163	15	--	--	--	6	--
India	--	--	--	91	--	--	--	300
Ireland	--	--	(2/)	249	53	(2/)	--	--
Italy	--	--	302	500	44	--	--	--
Japan	--	53	259	4,260	88	1	--	15
Korea, Republic of	--	379	--	--	--	--	--	--
Mexico	6	9	23	12	3	2	--	--
Netherlands	--	361	73	55	45	--	--	(2/)
Norway	--	--	481	1,270	17	--	--	--
Russia	--	--	4,000	35,500	1,590	--	--	--
South Africa, Republic of	--	--	39,100	22,900	4,880	557	46	8,720
Switzerland	--	--	869	1,140	154	65	--	259
Taiwan	--	280	(2/)	324	--	--	--	--
United Kingdom	--	1,260	3,410	9,270	614	73	--	116
Other	--	22	29	4	--	1	--	(2/)
Total	6	3,220	56,500 3/	92,500	7,820	926	55	9,880
			Exports					
Australia	--	--	99	124		--		
Belgium	--	20,900	2,670	5,480	60	--		
Brazil	--	--	17	--	--	--		
Canada	1	1,520	1,130	1,120	8	3 4/		
China	--	1	--	100	4	1 4/		
Denmark	--	--	3	24	--	--		
Finland	--	--	42	1	--	--		
France	156	4	202	728	--	2 4/		
Germany	--	802	1,810	1,480	135	17 4/		
Greece	--	--	1	11	--	--		
Hong Kong	--	3	20	14	--	12 4/		
Ireland	--	--	568	327	64	--		
Israel	--	--	274	249	--	--		
Italy	--	495	2	470	--	1 4/		
Japan		8,770	3,770	5,640	267	2 4/		
Korea, Republic of	27		1,170	651	--	--		
Malaysia	--	--	610	--	--	--		
Mexico	--	--	717	3,280	1	1 4/		
Netherlands	--	--	90	2,660	--	--		
New Zealand	--	--	--	26	1	1 4/		
Norway	--	--	4	69	--	--		
Singapore	--	--	3	861	--	--		
South Africa, Republic of	(5/)	--	--	203	15	--		
Spain	5	--	4	23	--	--		
Sweden	5	232	52	307	--	--		
Switzerland	7	186	1,150	836	--	--		
Taiwan	--	--	113	2,590	--	1 4/		
Turkey	--	--	--	--	--	--		
United Kingdom	(5/)	9,180	956	2,560	237	24 4/		
Other	1	1	9	65	(2/)	3 4/		
Total	202	42,100	15,500	29,900	791	68		

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Of this amount, 2,140 kilograms was in the form of platinum coins.

4/ Includes osmium and ruthenium.

5/ Data withheld pending verification by the Bureau of the Census.

TABLE 2
PLATINUM-GROUP METALS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Kilograms)

Country 3/	1990	1991	1992	1993	1994 e/
Platinum:					
Australia e/ 4/	100	100	100	100	100
Canada e/ 5/	5,040	4,680	4,800	5,000 r/	6,000
Colombia	1,320	1,600	1,960	1,720 r/	1,800
Ethiopia e/	2	1	1	1	1
Finland e/	60	60	60	60	60
Japan 6/	1,430	988	629	661 r/	700
Russia e/ 7/	XX	XX	28,000	20,000	15,000
Serbia and Montenegro 8/	XX	XX	19 r/	15 r/ e/	15
South Africa, Republic of e/ 5/	87,800	88,900	94,900	109,000 r/	102,000
U.S.S.R. e/ 7/ 9/	31,000	30,000	XX	XX	XX
United States e/ 10/	1,810	1,730	1,840	1,800	2,000
Yugoslavia 8/ 11/	21	22	XX	XX	XX
Zimbabwe	21	19	9	4 r/	10
Total	129,000	128,000	132,000	138,000 r/	128,000
Palladium:					
Australia e/ 4/	400	400	400	400	400
Canada e/ 5/	5,270	6,440	5,800	6,000 r/	7,000
Finland e/	100	100	100	100	100
Japan 6/	1,050	1,050	986	1,180 r/	1,200
Russia e/ 7/	XX	XX	70,000	50,000	40,000
Serbia and Montenegro 8/	XX	XX	130 r/	125 r/ e/	125
South Africa, Republic of e/ 5/	38,300	38,000	41,000	48,000 r/	44,000
U.S.S.R. e/ 7/ 9/	84,000	82,000	XX	XX	XX
United States e/ 10/	5,930	6,050	6,470	6,500	6,400
Yugoslavia 8/ 11/	130	155 r/	XX	XX	XX
Zimbabwe	31	30	19	11 r/	20
Total	135,000	134,000	125,000	112,000 r/	99,200
Other Platinum-group Metals:					
Canada e/ 5/	1,400	586	1,310	1,440 r/	1,970
Russia e/ 7/	XX	XX	6,000	4,000	3,000
South Africa, Republic of e/ 5/	15,800	16,000	17,000	19,000 r/	18,000
U.S.S.R. e/ 7/ 9/	10,000	9,500	XX	XX	XX
Total	27,200	26,100	24,300	24,400 r/	23,000
Grand total	291,000	288,000	282,000 r/	275,000 r/	250,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 4, 1995. Platinum-group metal production by Germany, Norway, and the United Kingdom is not included in this table because the production is derived wholly from imported metallurgical products and to include it would result in double counting.

3/ In addition to the countries listed, China, Indonesia, Papua New Guinea, and the Philippines are believed to produce platinum-group metals, and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. However, a part of this output not specifically reported by country is presumably included in this table credited to Japan.

4/ Platinum-group metals recovered from nickel ore processed domestically. Platinum-group metals extracted from exported ores are believed to be included in the production figures for Japan, and may be included in figures for other receiving countries.

5/ Country reports only total of platinum-group metals produced. Figures for constituent metals are U.S. Bureau of Mines estimates.

6/ Production derived entirely from imported ores.

7/ All production in the U.S.S.R. for 1990-91 came from Russia.

8/ All production in Yugoslavia for 1990-91 came from Serbia and Montenegro.

9/ Dissolved in Dec. 1991.

10/ Estimates for the Stillwater Mine, from published sources. A very small quantity of byproduct platinum and palladium produced from gold-copper ores was excluded.

11/ Dissolved in Apr. 1992.

POTASH

By James P. Searls

The term "potash" was originally applied to potassium carbonate-potassium hydroxide recovered in iron "pots" from washings of wood "ashes." Currently, "potash" is commonly used in connection with a variety of water soluble compounds, all containing the element potassium.

Potash can be potassium chloride (KCl or muriate of potash or MOP), potassium sulfate (K_2SO_4 or sulfate of potash or SOP), potassium-magnesium sulfate ($K_2SO_4MgSO_4$ or sulfate of potash magnesia), potassium nitrate (KNO_3 or saltpeter), or mixed sodium-potassium nitrate (Chilean saltpeter).

Potash is primarily a fertilizer that is important to society as part of the "Green Revolution." The Green Revolution slowed the conversion of fragile and marginal lands to crop lands, while allowing human populations to continue increasing by continuing to provide low cost food. Fixed nitrogen, water-soluble phosphorus, and water-soluble potassium are the main fertilizers. There are no substitutes for these three fertilizers, but there are minor, alternative sources, such as animal manure. These three fertilizers plus boron, calcium, magnesium, sulfur, zinc, as well as pesticides, disease-resistent seeds, mechanization, and the knowledge to use technologies, allow less than 2% of estimated 1994 U.S. working population to be farmers and still feed all the rest of the United States in 1992 for about 12.5% of averge personnel income.

Potassium chloride accounted for about 70% of potash sales by domestic producers; potassium sulfate was more than 15% of sales by domestic producers. For domestic consumption of potash when imports and exports also are considered, potassium chloride was about 95% of total consumption, while potassium sulfate was about 3% of consumption. It is estimated that 10% of total sales went to nonagricultural end uses. The weighted average price for all types and grades of potash rose slightly from that in 1993. Apparent domestic consumption of potash increased in 1994 by nearly 6% from 1993 as midwestern farmers gauged 1) the 1994 demand for crops after the 1993 floods and 2) the reduced farm commodity carryovers of calendar year 1993 or cropyear 1993-94.

Legislation and Government Programs

The suspension agreement between the International Trade Administration of the U.S. Department of Commerce and the Canadian potash producers continued for another year. The U.S. Department of Justice, Anti-Trust Division, quietly continued its investigation of potash producers for price fixing.

The civil antitrust lawsuits for collusive pricing, in U.S. Federal District Court in St. Paul, MN, continued against the Canadian and some U.S. potash producers, in 1994. No trial date has been announced. No trial date has been announced concerning a similar, continuing lawsuit in a California State Court.

Production

In the United States in 1994 the potash producers sold about 1.4 million tons[1] for a marketable potash value, f.o.b. mine, of about $284 million, due to the steady or increasing prices for muriate of potash. Three mines have closed since 1978, and a fourth will probably close before 2010. It is possible that, if the price for KCl stays relatively steady, one of those closed mines may reopen because of mining technology improvements and the use of a different mill. Domestic production of potash declined by about 7% as one Carlsbad firm reduced standard muriate of potash production. This firm was not profitable enough to buy compactors to produce coarse and granular muriate of potash. Standard muriate of potash is rarely sold into the domestic market and shipping costs to reach foreign markets (such as China) for standard product are too high to sell at a profit given the present price in that market.

The U.S. Bureau of Mines developed potash domestic data from voluntary semiannual surveys of U.S. operations. Of the 11 survey requests sent to operations in both the first and second half of the year, 10 responded. Data from the responses are estimated to consist of about 97% of total production shown in table 1.

In 1994, the Carlsbad, NM, producers were Eddy Potash Inc., owned by Trans-Resources Inc.; IMC Global Operations Inc., owned by IMC Global Inc.; Mississippi Potash, Inc., owned by Mississippi Chemical Corp.; New Mexico Potash, Inc., owned by Trans-Resources; and Western Ag-Minerals Inc., owned by Rayrock Resources of Toronto, Canada.

In Utah, the potash producers during 1994 were Great Salt Lake Minerals Corp. (GSLMC), affiliated with Harris Chemical Group; Moab Salt Inc., owned by Texasgulf Chemical Co. of Elf Aquitaine Inc.; and Reilly-Wendover of Reilly Industries Inc. Late in 1994, GSLMC proposed the purchase of Reilly's Wendover facility; the purchase was not finalized by the end of the year.

In California, North American Chemical Co., managed by Harris Chemical Group, produced KCl and K_2SO_4. North American Chemical sells its potash product through the GSLMC office in Kansas.

In Michigan, Kalium Chemical Ltd. continued pilot-plant development of a deep ore body by solution mining technology to extract KCl from that ore.

Potash Corp. of Saskatchewan continued to market potash exports for three domestic producers as a cost-cutting effort.

Consumption

According to the Potash & Phosphate Institute (P&PI), shipments of agricultural potash from Canadian and U.S. producers to U.S. consumers increased by 9% compared with those in 1993. Shipments of nonagricultural potash to U.S. consumers increased about 14% for a total increase in shipments of less than 10%.

The largest consuming region in the United States was the Corn Belt (Illinois, Indiana, Iowa, Missouri, and Ohio). It received about 44% of P&PI reported sales or about 2.17 million tons. The Corn Belt received 13% more potash in 1994 than in 1993. The second largest consuming region in the United States was the Lake States (Michigan, Minnesota, and Wisconsin) which took about 740,000 tons, 15% of P&PI sales, and a 9% increase from 1993. The third largest consuming region of potash was the southeastern states (Alabama, Florida, Georgia, and South Carolina), which took about 475,000 tons, 10% of P&PI sales and about 5% increase from 1993.

Stocks

Yearend producers stocks decreased about 23% compared with those of 1993. Yearend stocks represented about 17% of annual production or about 8.7 weeks of average production.

Prices

The weighted average annual price, $193.32 per ton f.o.b. mine, of U.S. potash sales of all types and grades was unchanged from 1993. The average price was $188.60 for the first half of the year and $199.05 for the second half of the year. The average annual price for the three grades of KCl (standard, coarse, and granular) was $131.01, unchanged from 1993. For the full calendar year, standard grade KCl was $124.78 per ton, down 4%; coarse grade, $130.93 per ton, up 5%; and granular grade, $134.69 per ton, up 6%.

World Review

The world's potash producers remained in overcapacity for another year. Most producers around the world operated at partial capacity to maintain prices. Using an estimated world capacity of 29.9 million tons of capacity[2], the world produced at about 75% of capacity. The Canadian potash industry again operated at about 70% capacity, 55% for Potash Corp. of Saskatchewan and 90% for all other Canadian producers. In the United States, New Mexico producers operated at about 85% capacity for the year. The former U.S.S.R. producers operated at about 60% capacity. One source[3] noted modest price increases of $5 to $15 per ton of muriate of potash product (much lower than the price increases for nitrogen/phosphorus compounds) on the world market between September 1993 and September 1994, due to Canadian and former U.S.S.R. efforts to raise prices by keeping producer stocks relatively low.

Belarus.—The Belarus potash mines operated at about 45% capacity for the year. As the exporter for Russia and Belarus, International Potash Corp. gained more control over potash exports from the former U.S.S.R. onto the world market in the first quarter of the year, and potash prices rose slightly.

Canada.—Vigoro Co., owner of Kalium Chemical and the Kalium Chemical solution mine in Belle Plaine, Saskatchewan, announced in November[4] that it was considering purchasing the assets of Central Canada Potash, a division of Noranda Minerals Inc., with an underground mine at Colonsay, Saskatchewan, Canada.

The Canadian Director of Investigations and Research, under the Competition Act, dropped the investigation of collusive price setting[5] in Canada in the second quarter of 1994.

Chile.—In Chile, Sociedad Quimica y Minera de Chile (Soquimich) announced plans to invest in the Minsal project[6] and bring about 50,000 tons per year of muriate of potash as feed for its high grade potassium nitrate production. Soquimich also started up the 50,000-ton-per-year potassium nitrate plant in November, which will use the Minsal muriate as feed to convert sodium nitrate to potassium nitrate. The KCl exporter of Canada, Canpotex Ltd., announced an agreement to invest in the Kap Resources project in Chile. This project will develop a caliche region just south of Soquimich for potassium nitrate and iodine.

China.—In September the Government of China issued a regulation that it would again become the sole importer of fertilizers into China.[7]

Japan.—In early October, the major fertilizer importer of Japan, Zen-Noh, agreed to a $4 to $5 per ton product, muriate of potash, increase with Canpotex Ltd., the major potash exporter of Canada. The agreements between these two firms are usually trend setters for the world market.

Jordan.—Peace between Israel and Jordan may allow each country's potash producer to use the other's transportation facilities to the ports of Ashdod or Aquaba. Arab Potash of Jordan opened a 240,000-ton-per-year muriate of potash plant in June.

Thailand.—The Udon Thani potash project, dropped by then Agrico Chemical and Thai Central Cement in 1986, has been carefully investigated for reserves of sylvinite (the ore leading to muriate of potash production) by Vancouver-based Asian Pacific Resources Ltd.[8] The proposed Association of South-east Asian Nations project at Bamnet Narong to recover muriate of potash from carnallite was waiting for more promotion.

Outlook

If funding is reduced for the U.S. Department of Agriculture, it is not clear for 1996 or beyond what the effect on farmers will be but it could easily cause more variability in planting and fertilization, and less predictability to the potash usage, season by season. This, in turn, may cause wider swings in potash availability and prices.

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[1] All tonnages are reported in metric tons (tonnes), K_2O equivalent, unless otherwise noted.

[2] Potash Corporation of Saskatchewan, 1994 Annual Report, pp. 12-13, 26.

[3] Fertilizer Markets, British Sulphur North America Inc., Sept. 19, 1994, p. 9.

[4] ———, Nov. 21, 1994, p.1.

[5] Potash Corporation of Saskatchewan Inc., 1994 Annual Report, p. 6.

[6] Mining Journal (London), v. 322, No. 8274, May 6, 1994, p. 326.

[7] Fertilizer Markets, British Sulphur North America Inc., Sept. 26, 1994, p. 2.

[8] ———, March 7, 1994, p. 3.

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TABLE 1
SALIENT POTASH 1/ STATISTICS

(Thousand metric tons and thousand dollars, unless otherwise specified)

		1990	1991	1992	1993	1994
United States:						
Production		3,360	3,450	3,340	3,070	2,830
K_2O equivalent		1,710	1,750	1,710	1,510	1,400
Sales by producers		3,390	3,330	3,470	3,030	2,970
K_2O equivalent		1,720	1,710	1,770	1,480	1,470
Value 3/		$303,000	$305,000	$334,000	$286,000	$284,000
Average value per ton of product	dollars	89.46	91.52	96.45	94.36	95.94
Average value per ton of K_2O equivalent	do.	176.80	178.20	189.36	192.72	193.32
Exports 4/		1,020	1,260	1,330	935	997
K_2O equivalent		470	624	663	415	462
Value 5/		$136,000	NA	NA	NA	NA
Imports for consumption 4/ 6/		6,950	6,860	7,010	7,200	7,920
K_2O equivalent		4,160	4,160	4,250	4,360	4,740
Customs value		$546,000	$550,000	$580,000	$578,000	$642,000
Consumption, apparent 7/		9,330	8,930	9,150	9,300	9,890
K_2O equivalent		5,410	5,240	5,350	5,430	5,750
Yearend producers' stocks, K_2O equivalent		303	343	283	305	234
World: Production, marketable K_2O equivalent		27,500	26,100	23,900	20,300 r/	22,500

r/ Revised. NA Not available.

1/ Includes muriate and sulfate of potash, potassium magnesium sulfate, and some parent salts. Excludes other chemical compounds containing potassium.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

3/ F.o.b. mine

4/ Excludes potassium chemicals and mixed fertilizers.

5/ F.a.s. U.S. port.

6/ Includes nitrate of potash.

7/ Calculated from sales plus imports minus exports.

TABLE 2
PRODUCTION, SALES, AND INVENTORY OF U.S. PRODUCED POTASH, BY TYPE AND GRADE 1/

(Thousand metric tons and thousand dollars)

Type and grade	Production				Sold or used						Stocks, end of 6-month period			
	Gross weight		K_2O equivalent		Gross weight		K_2O equivalent		Value e/ 2/		Gross weight		K_2O equivalent	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
January-June:														
Muriate of potash, 60% K_2O minimum:														
Standard	274	299	168	182	267	292	163	178	21,100	21,000	99	151	60	92
Coarse	62	64	38	39	98	68	60	42	7,260	5,340	9	9	5	6
Granular	525	406	319	247	621	529	377	321	46,800	42,700	79	52	48	32
Chemical	7	5	4	3	7	6	4	4	W	W	2	(3/)	1	(3/)
Potassium sulfate	282	238	143	123	286	252	145	130	47,600	41,500	63	66	32	34
Other potassium salts 4/	419	441	114	118	506	471	137	130	W	W	148	207	37	50
Total	1,570	1,450	787	713	1,790	1,620	887	806	167,000	152,000	399	485	183	213
July-December:														
Muriate of potash, 60% K_2O minimum:														
Standard	272	192	167	118	227	251	139	153	18,384	20,400	144	92	88	56
Coarse	89	62	54	38	84	50	51	30	6,774	4,120	14	22	8	13
Granular	410	461	249	281	313	399	191	243	25,313	33,400	175	115	106	70
Chemical	6	8	4	5	7	6	4	4	W	W	1	2	1	2
Potassium sulfate	213	250	108	129	196	230	100	118	33,136	38,200	80	86	40	44
Other potassium salts 4/	508	401	137	116	418	411	113	116	W	W	238	197	62	49
Total	1,500	1,370	719	686	1,250	1,350	597	664	119,000	132,000	652	514	305	234
Grand total	3,070	2,830	1,510	1,400	3,030	2,970	1,480	1,470	286,000	284,000	XX	XX	XX	XX

e/Estimated. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, may not add to totals shown.

2/ F.o.b. mine.

3/ Less than 1/2 unit.

4/ Includes soluble muriate, manure salts, and potassium magnesium sulfate.

TABLE 3
PRODUCTION AND SALES OF POTASH IN NEW MEXICO 1/

(Thousand metric tons and thousand dollars)

Period	Crude salts 2/ (mine production)		Marketable potassium salts				
			Production		Sold or used		
	Gross weight	K2O equivalent	Gross weight	K2O equivalent	Gross weight	K2O equivalent	Value e/ 3/
1993:							
January-June	6,320	794	1,290	637	1,490	725	126,000
July-December	6,640	822	1,250	581	1,010	465	90,100
Total	13,000	1,620	2,550	1,220	2,500	1,190	216,000
1994:							
January-June	6,400	814	1,200	570	1,370	670	120,000 r/
July-December	6,220	762	1,110	539	1,070	513	97,800
Total	12,600	1,580	2,300	1,110	2,450	1,180	218,000

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Sylvinite and langbeinite.

3/ F.o.b. mine.

TABLE 4
SALIENT U.S. SULFATE OF POTASH STATISTICS 1/ 2/

(Thousand metric tons of K_2O equivalent and thousand dollars)

	1990	1991	1992	1993	1994
Production	219	230	243	251	252
Sales by producers	221	211	267	245	249
Value 3/	$70,200	$67,400	$87,900	$80,800	$79,700
Exports 4/	124	104	158	114	139
Value 5/	$43,300	NA	NA	NA	NA
Imports 4/	26	29	35	45	36
Value 6/	$11,000	$11,800	$13,600	$17,300	$19,000
Consumption, apparent 7/	123	136	144	176	145
Yearend producers stocks	39	58	34	40	44

NA Not available.

1/ Excluding potassium magnesium sulfate.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

3/ F.o.b. mine.

4/ Bureau of the Census.

5/ F.a.s. U.S. port.

6/ C.i.f. to U.S. port.

7/ Calculated from sales plus imports minus exports.

TABLE 5
SALES OF NORTH AMERICAN POTASH, BY STATE OF DESTINATION 1/

(Metric tons of K2O equivalent)

State	Agricultural potash		Nonagricultural potash	
	1993	1994	1993	1994
Alabama	92,500	91,800	162,000	201,000
Alaska	1,270	657	1,380	717
Arizona	2,810	4,760	1,090	1,100
Arkansas	54,800	73,700	850	939
California	89,500	93,600	8,440	9,010
Colorado	15,000	14,200	2,310	3,270
Connecticut	1,710	3,450	552	1,520
Delaware	17,700	21,400	53,400	40,800
Florida	147,000	159,000	2,010	2,560
Georgia	159,000	163,000	1,900	1,850
Hawaii	7,030	4,380	47	57
Idaho	38,800	40,300	411	964
Illinois	568,000	607,000	7,420	8,960
Indiana	317,000	403,000	3,630	4,640
Iowa	417,000	455,000	6,430	7,280
Kansas	48,100	51,600	5,680	7,760
Kentucky	125,000	118,000	759	943
Louisiana	144,000	139,000	2,830	3,330
Maine	5,890	5,630	670	1,030
Maryland	18,400	33,600	979	564
Massachusetts	3,730	4,540	413	876
Michigan	182,000	198,000	7,270	7,330
Minnesota	271,000	305,000	5,630	6,960
Mississippi	64,300	62,300	49,400	53,300
Missouri	237,000	263,000	4,920	4,510
Montana	15,800	17,500	86	114
Nebraska	37,600	40,000	2,320	2,070
Nevada	142	302	64	112
New Hampshire	708	738	221	184
New Jersey	5,280	7,120	670	1,120
New Mexico	3,330	6,480	18,300	15,800
New York	61,700	60,900	705	1,310
North Carolina	90,000	109,000	1,020	1,210
North Dakota	29,800	32,400	28	29
Ohio	383,000	447,000	73,700	86,800
Oklahoma	25,400	33,600	2,090	2,760
Oregon	34,500	35,400	1,280	1,320
Pennsylvania	52,300	71,500	3,120	4,260
Rhode Island	953	742	728	1,550
South Carolina	58,100	64,100	61	295
South Dakota	13,600	17,900	238	312
Tennessee	129,000	122,000	402	397
Texas	170,000	177,000	20,100	22,600
Utah	20,000	4,380	8,620	3,740
Vermont	6,250	5,610	138	171
Virginia	87,800	81,600	293	232
Washington	41,900	47,000	3,010	2,390
West Virginia	4,100	2,820	992	1,160
Wisconsin	227,000	239,000	50,800	69,800
Wyoming	3,150	3,490	1,790	828
Total	4,530,000	4,940,000	521,000	592,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Potash & Phosphate Institute.

TABLE 6
SALES OF NORTH AMERICAN MURIATE OF POTASH TO U.S. CUSTOMERS, BY GRADE 1/

(Thousand metric tons of K_2O equivalent)

Grade	1993	1994
Agricultural:		
Standard	262	257
Coarse	1,980	2,340
Granular	1,690	1,680
Soluble	395	467
Total	4,330	4,750
Nonagricultural:		
Soluble	106 2/	97
Other	415 2/	490
Total	521	587
Grand total	4,850	5,340

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ For 1993 nonagricultural data were revised.

Source: Potash & Phosphate Institute.

TABLE 7
PRICES 1/ OF U.S. POTASH, BY TYPE AND GRADE

(Dollars per metric ton of K_2O equivalent)

Type and grade	1993		1994	
	January-June	July-December	January-June	July-December
Muriate, 60% K_2O minimum:				
Standard	128.88	132.60 r/	117.78	132.90
Coarse	121.04	130.10 r/	127.86	135.13
Granular	124.08	132.62	132.62	137.43
All muriate 2/	125.08	132.30 r/	127.37	135.64
Sulfate, 50% K_2O minimum	327.76	332.24	318.84	321.70

r/ Revised.

1/ Average prices, f.o.b. mine, based on sales.

2/ Excluding soluble and chemical muriates.

TABLE 8
U.S. EXPORTS OF POTASH, BY TYPE 1/

	Approximate average K2O content (percent)	Quantity (metric tons)	
		Product	K2O equivalent
1993:			
Potassium chloride, all grades	61	361,000	220,000
Potassium sulfate	51	223,000	114,000
Potassium magnesium sulfate	22	333,000	73,200
Potassium nitrate	45	17,800	8,000
Total	XX	935,000	415,000
1994:			
Potassium chloride, all grades	61	419,000	256,000
Potassium sulfate	51	273,000	139,000
Potassium magnesium sulfate	22	298,000	63,700
Potassium nitrate	45	6,510	2,930
Total	XX	997,000	462,000

XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 9
U.S. EXPORTS OF POTASH, BY COUNTRY

(Metric tons of product)

Country	Potassium chloride		Potassium sulfate, all grades 2/		Potassium nitrate		Total	
	1993	1994	1993	1994	1993	1994	1993	1994
Argentina	85	98	2,560	3,290	--	--	2,640	3,380
Australia	2,730	140	7,990	10,800	--	20	10,700	10,900
Bangladesh	--	--	1,510	--	--	--	1,510	--
Barbados	--	930	--	--	--	--	--	930
Belgium	362	208	--	4,450	--	14	362	4,680
Belize	1,170	2,440	--	--	--	--	1,170	2,440
Bolivia	120	1,690	--	--	--	--	120	1,690
Brazil	103,000	15,500	2,550	12,600	--	--	106,000	28,100
Canada	4,330	4,680	109,000	71,400	4,400	5,240	118,000	81,300
Chile	32,800	50,300	25,900	22,300	--	--	58,700	72,600
China	--	--	112,000	132,000	--	--	112,000	132,000
Colombia	2,000	23,000	7,290	3,500	--	--	9,290	26,500
Costa Rica	28,000	24,100	26,600	44,500	--	--	54,600	68,700
Cote d'Ivoire	--	--	--	6,500	--	--	--	6,500
Dominican Republic	9,760	23,600	2,730	3,330	19	9	12,500	26,900
Ecuador	13,800	29,400	3,500	--	--	4	17,300	37,900
Egypt	--	--	--	468	--	--	--	468
El Salvador	--	3,300	2	1,670	--	--	2	4,970
Fiji	--	2,980	--	--	--	--	--	2,980
France	--	25,300	--	--	--	--	--	25,300
Guatemala	--	11,100	2,110	4,500	--	--	2,110	15,600
Guyana	--	2,990	--	2	--	--	--	2,990
Haiti	--	354	--	--	--	--	--	354
Honduras	3,000	9,960	16,400	8,230	--	--	19,400	18,200
Indonesia	--	--	84	--	--	--	84	--
Italy	21,500	33,400	--	7	1	--	21,600	33,400
Jamaica	2,800	--	--	--	--	--	2,800	--
Japan	28,100	20,700	115,000	136,000	9,040	1	152,000	156,000
Jordan	--	--	57	--	--	--	57	--
Korea, Republic of	6,440	3,850	8,030	6,070	2	4	14,500	9,930
Kuwait	--	--	59	--	--	--	59	--
Malaysia	--	27,300	25,200	43	--	--	25,200	27,300
Martinique	420	4,000	1	--	--	--	421	4,000
Mexico	50,800	40,000	59,600	59,000	4,290	1,190	115,000	100,000
New Zealand	--	2,410	--	6	--	--	--	2,410
Nicaragua	--	2,700	--	1,010	--	--	--	3,710
Panama	4,180	6,040	996	800	--	--	5,180	6,840
Peru	5,640	22,200	4,730	5,420	--	--	10,400	27,700
Philippines	6	8,670	1	55	--	--	7	8,720
Russia	62	119	--	--	--	--	62	119
Saudi Arabia	--	--	3,300	1,100	1	--	3,300	1,100
Singapore	--	--	205	149	--	--	205	149
South Africa, Republic of	--	--	--	266	--	--	--	266
St. Lucia	--	--	--	65	--	--	--	65
Sweden	1,460	731	22	--	--	--	1,480	731
Switzerland	--	--	--	298	--	--	--	298
Taiwan	--	20	180	140	--	--	180	160
Thailand	10,300	10,300	10,400	3,560	--	4	20,700	13,800
Trinidad and Tobago	2,390	1,620	--	142	--	--	2,390	1,770
Turkey	--	--	--	102	--	--	--	102
Uruguay	--	3,100	--	723	--	--	--	3,820
Venezuela	25,900	97	2,920	13,700	--	6	28,800	13,800
Zimbawe	--	--	5,050	5,000	--	--	5,050	5,000
Other	6	54	153	118	20	24	179	196
Total	361,000	419,000	556,000	563,000	17,800	6,520	935,000	997,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes potassium magnesium sulfate.

Source: Bureau of the Census.

TABLE 10
U.S IMPORTS FOR CONSUMPTION OF POTASH, BY TYPE 1/

	Approximate average K_2O content (percent)	Quantity (metric tons)		Value (thousands)	
		Product	K_2O equivalent e/	Customs	C.i.f.
1993:					
Potassium chloride	61	7,050,000	4,300,000	$548,600	$649,000
Potassium sulfate	51	87,300	44,500	15,400	17,300
Potassium nitrate	45	28,100	12,700	7,830	8,750
Potassium sodium nitrate mixture	14	38,900	5,450	5,970	6,570
Total	XX	7,200,000	4,360,000	578,000	682,000
1994:					
Potassium chloride	61	7,790,000	4,740,000	614,000	716,000
Potassium sulfate	51	70,900	36,200	17,300	19,000
Potassium nitrate	45	16,400	7,360	4,280	5,240
Potassium sodium nitrate mixture	14	45,700	6,400	6,180	6,810
Total	XX	7,920,000	4,790,000	642,000	747,000

e/ Estimated. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census, as adjusted by the U.S. Bureau of Mines.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF POTASH, BY COUNTRY 1/

Country	Metric tons of product										Total value (thousands)			
	Potassium chloride		Potassium sulfate		Potassium nitrate		Potassium sodium nitrate		Total		Customs		C.i.f.	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Belarus	198,000	302,000	--	--	--	--	--	--	198,000	302,000	$16,300	$24,000	$18,600	$28,600
Belgium	3,000	2,500	15,800	8,720	--	--	--	--	18,800	11,200	2,920	1,960	3,460	2,280
Canada	6,400,000	7,230,000	2,770	11,100	14	1	12,300	20,300	6,420,000	7,260,000	497,000	577,000	590,000	671,000
Chile	--	--	--	--	13,800	10,200	26,590	25,300	40,400	35,500	7,760	5,530	8,630	6,330
Denmark	--	--	--	--	1,220	2,070	--	--	1,220	2,070	458	651	557	867
Dominican Republic	--	--	--	--	169	226	--	--	169	226	61	88	67	97
France	--	--	--	6,760	--	--	--	--	--	6,760	--	3,000	--	3,060
Germany	64,400	49,000	67,100	42,800	247	19	--	--	132,000	91,800	15,800	10,800	18,200	12,700
Israel	232,000	61,100	--	--	12,600	3,610	--	--	245,000	64,700	25,700	6,930	28,600	7,990
Japan	6	--	407	307	25	45	56	118	494	470	309	129	347	177
Jordan	7,300	5,000	--	--	--	--	--	--	7,300	5,000	647	425	788	521
Latvia	34,500	33,000	--	--	--	--	--	--	34,500	33,000	2,300	2,480	2,820	3,050
Mexico	--	--	--	73	6	--	--	--	6	73	6	24	6	25
Netherlands	28	--	1,200	1,150	--	--	--	46	1,230	1,200	262	219	264	257
Nigeria	--	29	--	--	--	--	--	--	--	29	--	6	--	7
Poland	--	--	--	--	36	91	--	--	36	91	19	49	24	58
Russia	109,000	109,000	--	--	43	51	--	--	109,120	109,000	7,911	8,290	9,510	9,780
Sweden	21	2	--	--	--	--	--	--	21	2	20	3	22	3
United Kingdom	319	428	7	--	--	--	--	11	326	439	156	137	193	165
Other	--	--	--	--	(2/)	10	--	--	--	10	--	9	--	11
Total	7,050,000	7,790,000	87,300	70,900	28,100	16,400	38,900	45,700	7,200,000	7,920,000	578,000	642,000	682,000	747,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Revised to zero.

Source: Bureau of the Census.

TABLE 12
MARKETABLE POTASH: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons of K2O equivalent)

Country	1990	1991	1992	1993	1994 e/
Belarus	XX	XX	3,310	1,950	2,510
Brazil	66	101	85	173	240
Canada	6,990	7,410	7,270	6,840	8,040 3/
Chile e/ 4/	45 r/	55	55	55	70
China e/	29	32	21	25	25
France	1,290	1,130	1,140	890 r/ e/	870
Germany:					
Eastern states	2,650	XX	XX	XX	XX
Western states	2,310	XX	XX	XX	XX
Total	4,960	3,860	3,460 r/	2,860 r/	3,290
Israel	1,310	1,320	1,300 r/ e/	1,310 r/	1,260
Italy	68	31	86	-- r/ e/	--
Jordan	841	818	808	822 r/	930
Russia	XX	XX	3,450	2,600	2,480
Spain	686	585	594	661 r/	684
Ukraine	XX	XX	98 r/	88 r/ e/	78
U.S.S.R. 5/	9,000	8,560 e/	XX	XX	XX
United Kingdom	488	495	529 r/	550 r/	580
United States	1,710	1,750	1,710	1,510	1,400 3/
Total	27,500	26,100	23,900 r/	20,300 r/	22,500

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through Apr. 25, 1995.

3/ Reported figure.

4/ Data from Comisión Chilena del Cobre. This is the sum of potassium chloride production and exports of mixed sodium-potassium nitrates.

5/ Dissolved in Dec. 1991.

PUMICE AND PUMICITE

By Wallace P. Bolen

Pumice and pumicite consumption in the United States increased nearly 4% in 1994 compared with that of 1993, according to the U.S. Bureau of Mines (USBM). The increase was attributable strictly to increased consumption of domestically produced pumice and pumicite as imports and exports were unchanged. By volume, most imports were for construction related uses with small but significant amounts used for abrasives and stonewashing. Zaire imported pumice into the United States for the first time in 1994. *(See table 1 .)*

Production

Pumice and pumicite sold or used by U.S. producers increased to 490,000 metric tons with a value of $11.8 million. The average price of pumice continued to fall from $25.68 per metric ton to $24.08 per ton. As in 1993, the average value decreased because less of the costlier stonewashing grade pumice was consumed while more construction grade pumice was consumed, hence the lower average price. Oregon remained as the largest source of pumice followed by, in descending order, New Mexico, Idaho, California, Arizona, and Kansas.

Domestic production data for pumice and pumicite were developed by the USBM from one voluntary survey of U.S. operations. Thirteen companies with 14 active operations contributed 100% of the quantity and value of pumice and pumicite sold and used as shown in table 1. One of the companies, with one operation, did not respond to the 1994 survey. This company's sold and used data were estimated.

Domestic producers were Tufflite Inc., Phoenix, AZ; California Industrial Minerals Co., Friant, CA; Glass Mountain Pumice Inc., Tulelake, CA; U.S. Pumice Co., Chatsworth, CA; Hess Pumice Products, Malad City, ID; Producers Pumice, Meridan, ID; Calvert Corp., Norton, KS; Kansas Minerals Inc., Mankato, KS; Copar Pumice Co. Inc., Espanola, NM; General Pumice Corp., Santa Fe, NM; Utility Block Co., Albuquerque, NM; Cascade Pumice Co., Bend, OR; and Central Oregon Pumice Co., Bend, OR.

Consumption

The amount of pumice sold or used by U.S. producers increased 4% as demand grew in the abrasives and building block markets. Demand continued to decrease for stone washing pumice as domestic sales fell 7%. Imports of stone washing grade pumice were thought to have experienced an even greater decrease although hard numbers were not available.

The most important market for pumice remained building block, consuming 64% of the total pumice sold or used in the United States. Other important uses, in descending order, were for horticultural and landscaping, 12%; stone washing laundries, 8%; abrasive uses, 7%; and concrete aggregate, 5%. The remaining pumice and pumicite was used for absorbent, diluents, filter aids, roofing granules, water treatment, and other unspecified uses. Because construction activity remained strong in 1994, construction related uses of pumice continued to be a robust market. Concrete aggregate and stonewashing markets declined in 1994 while all other market segments improved. *(See table 2.)*

Foreign Trade

Pumice imports in 1994 remained unchanged at 143,000 tons. Greece continued to be the largest source of imports but the amount of pumice imported dropped 47,000 tons or 41%. Zaire's first time imports to the United States of 56,000 tons represented 39% of total imports. Other major exporting countries to the United States were Ecuador, Italy, Mexico, and Turkey. Besides these countries, 14 other countries exported pumice to the United States.

Exports remained at 18,000 metric tons with a value of $5.7 million. Canada received 58% of U.S. exports while Japan received 14%. The remainder of exports went to 29 other countries located on every continent except Antarctica. *(See table 3.)*

World Review

Globally, Italy remained the dominant producer of pumice and pozzolan, with annual production around 5 million tons. Other leading countries in the production of pumice and related materials where Chile, France, Germany, Greece, Spain, Turkey, and the United States. Besides these countries, 19 other countries produced pumice around the world. *(See table 4.)*

Outlook

Consumption of pumice and pumicite in 1995 is expected to increase slightly from 1994, even though construction activity is expected to be slowing down. Stonewashing consumption will probably continue to decrease while both imports and exports will show some growth.

TABLE 1
SALIENT PUMICE AND PUMICITE STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States: Sold and used by producers:					
Pumice and pumicite	443	401	481	469	490
Value (f.o.b. mine and/or mill)	$10,700	$9,190	$14,900	$12,000	$11,800
Average value per ton	$24.13	$22.90	$30.99	$25.68	$24.08
Exports e/	20	13	13	18	18
Imports for consumption	280	118	257	143	143
Apparent consumption 2/	703	506	727	594	615
World: Production, pumice and related volcanic materials	11,500 r/	10,800	10,900 r/	11,200 r/	11,400 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Production plus imports, minus exports, plus adjustments for Government and industry stock changes.

TABLE 2
PUMICE AND PUMICITE SOLD AND USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

(Thousand metric tons and thousand dollars)

Use	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Abrasives 2/	31	3,390	35	3,660
Building block (includes decorative)	279	3,760	315	3,030
Concrete admixture and aggregate	43	883	24	751
Horticultural and landscaping	57	1,530	59	1,730
Laundries	42	1,870	38	1,870
Other 3/	17	618	19	770
Total	469	12,000	490	11,800

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits: may not add to totals shown.

2/ Includs cleaning and scouring compounds.

3/ Includes absorbent, diluents, filter aids, road construction and maintenance, roofing granules, and other unspecifed uses.

TABLES 3
TABLE 3-U.S. IMPORTS FOR CONSUMPTION OF PUMICE, BY CLASS AND COUNTRY 1/

(Thouand metric tons and thousand dollars)

Country	Crude or unmanufactured Quantity	Crude or unmanufactured Value	Wholly or partly unmanufactured Quantity	Wholly or partly unmanufactured Value
1993:				
Ecuador	9	664	--	--
Greece 2/	116	3,510	--	--
Italy	(3/)	6	1	454
Mexico	2	270	--	--
Turkey	15	1,920	--	--
Other 4/	(3/)	67	(3/)	182
Total	142	6,430	1	635
1994:				
Ecuador	4	373	--	--
Greece 2/	69	5,500	--	--
Italy	(3/)	57	1	472
Mexico	2	325	--	--
Turkey	11	1,220	--	--
Zaire 2/	56	4,500	--	--
Other 5/	(3/)	68	(3/)	119
Total	142	12,000	1	591

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The Journal of Commerce Port Import/Export Reporting Service data.

3/ Less than 1/2 unit.

4/ Includes Austria, Canada, Germany, Guatemala, India, Japan, Monaco, Taiwan, and the United Kingdom.

5/ Includes Austria, Canada, Chili, China, France, Germany, India, Israel, Japan, Republic of Korea, Pakistan , Syria, Taiwan, and the United Kingdom.

Source: Bureau of the Census.

TABLE 4
PUMICE AND RELATED MATERIALS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina 4/	118,000	69,700 r/	89,100 r/	89,000 r/	89,000
Austria: Trass	8,950	8,200	7,490	9,100 r/	9,000
Burkina Faso e/	10,000	10,000	10,000	8,000	8,000
Cameroon: Pozzolan e/	130,000	130,000	130,000	130,000	130,000
Cape Verde Islands: Pozzolan e/	53,000	53,000	53,000	25,000	5,000
Chile: Pozzolan	305,000	321,000	385,000	448,000 r/	450,000
Costa Rica e/	4,900	8,000	8,000	8,000	8,000
Dominica: Pumice and volcanic ash e/	100,000	100,000	100,000	100,000	100,000
Ecuador e/	34,000	33,500 5/	35,000	35,000	35,000
Ethiopia e/	23,000	37,000	49,000	40,000	40,000
France: Pozzolan and lapilli	336,000	400,000 e/	404,000	526,000 r/	500,000
Germany: Pumice (marketable) e/	318,000	366,000	591,000	647,000 r/ 5/	650,000
Greece:					
Pumice	665,000	445,000	400,000 e/	400,000 e/	400,000
Pozzolan	795,000	536,000	500,000 e/	500,000 e/	500,000
Guadeloupe: Pumice e/	220,000	230,000	220,000	210,000	210,000
Guatemala: Pumice	5,000 r/ e/	6,130 r/	6,590 r/	6,300 r/	6,000
Iceland	28,200	33,400	33,500	45,000 r/ e/	230,000
Iran	238,000	215,000	330,000	185,000 r/	200,000
Italy: e/					
Pumice and pumiceous lapilli	725,000	700,000	600,000	700,000	700,000
Pozzolan	4,500,000	4,500,000	4,400,000	4,500,000	4,500,000
Macedonia: Volcanic tuff e/	250,000	200,000	100,000	75,000	75,000
Martinique: Pumice e/	140,000	150,000	140,000	130,000	130,000
New Zealand	101,000	52,600	112,000 r/	50,000 e/	100,000
Serbia and Montenegro: Volcanic tuff	110,000 r/ e/	102,000 r/	109,000 r/	108,000 r/ e/	105,000
Slovenia: Volcanic tuff e/	100,000	90,000	50,000	40,000	40,000
Spain e/ 6/	900,000	800,000	800,000	700,000	700,000
Turkey e/	438,000	447,000	736,000	1,050,000 r/	1,000,000
United States (sold and used by producers)	443,000	401,000	481,000	469,000	490,000 5/
Yugoslavia: Volcanic tuff 7/	418,000	380,000	XX	XX	XX
Total	11,500,000 r/	10,800,000	10,900,000 r/	11,200,000 r/	11,400,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 4, 1995.

3/ Pumice and related volcanic materials are also produced in a number of other countries, including (but not limited to) Japan, Mexico, the former U.S.S.R., and Zaire; utput is not reported quantitatively, and available information is inadequate for the formulation of reliable estimates of output levels.

4/ Unspecified volcanic materials produced mainly for use in construction products (includes pumice, perlite, pozzolan and toba).

5/ Reported figure.

6/ Includes Canary Islands.

7/ Dissolved in Apr. 1992.

QUARTZ CRYSTAL

By Gordon T. Austin

Electronic-grade quartz crystal is single-crystal silica that is free from all visible defects and has piezoelectric properties that permit its use in electronic circuits for accurate frequency control, timing, and filtration. These uses generate practically all the demand for electronic-grade quartz crystal. A smaller amount of optical-grade quartz crystal is used as windows and lenses in specialized devices including some lasers.

More natural quartz crystal was consumed in electronic and optical applications until 1971, when cultured quartz crystal took the lead. Since that time cultured (synthetic) quartz has replaced natural crystal in practically all these applications. The use of natural quartz crystals for carvings and other gemstone applications continued; quartz crystals for this application are discussed in the Gemstones Annual Report of the U.S. Bureau of Mines.

Legislation and Government Programs

At yearend the National Defense Stockpile contained about 109,000 kilograms of natural quartz crystal. The Fiscal Year (FY) 1994 Annual Material Plan established a goal of zero and also authorized the disposal of the entire quartz crystal inventory during FY 1994. The stockpile material, which primarily consists of large natural crystals, could be absorbed by the specimen and gem material industry. Very little, if any, of the material would be consumed in the same applications as synthetic quartz crystal.

Strategic Considerations

Natural electronic-grade quartz crystal was initially designated as a strategic and critical material after World War II. Cultured quartz crystal was not commercially available at the time of U.S. stockpile acquisition. With the changing patterns of quartz consumption, the Federal Emergency Management Agency asked the National Materials Advisory Board to assess the requirements and related trends for stockpiling quartz. The final report was published in early 1985 and recommended changes in stockpile goals to reflect the declining dependence on natural quartz crystal.[1]

The National Defense Stockpile contains natural quartz in several weight classes and grades, including about 13,000 kilograms of material consisting of individual crystals weighing more than 10,000 grams each. Some of the individual quartz pieces in this weight class are suitable for generating mother seeds for cultured quartz crystal production. These large pieces were acquired from Brazil because similar materials were not available from a domestic source.[2]

Production

Coleman Quartz Inc., Jessieville, AR, is the only domestic company known to supply the feed material for cultured quartz crystal, called lascas. Coleman mined only during the summer months, but processed lascas year-round. Lascas was mined, crushed, and sized. Crushed and sized material was transported to the processing plant where operators rinsed it in oxalic acid and then in deionized water to remove external contaminants. Finally, hand sorting, drying, and examination on a light table completed the necessary processing. The material was then shipped to cultured quartz crystal producers in 45-kilogram (100-pound) bags in 20,000-kilogram lots. *(See table 1.)*

Four companies produced cultured quartz crystals during 1994. The two largest producers, Sawyer Research Products Inc. of Eastlake, OH, and Thermo Dynamics Corp. of Merriam, KS, were independent growers that produced crystal bars for domestic and foreign consumers in the crystal device fabrication industry. Motorola Inc. of Chicago, IL, produced quartz crystal for both internal consumption and the domestic device fabrication industry. P. R. Hoffman Material Processing Co. of Carlisle, PA, also reported outside sales. Bliley Electric Co. of Erie, PA, used crystals from inventory for internal consumption and did not produce during the year.

These companies produced cultured quartz crystal using a hydrothermal process in large pressure vessels, known as autoclaves. Seed crystals, very thin crystals cut to exact dimensions, were mounted on racks and suspended in the upper growth region of the vessel. Lascas was loaded in an open-mesh wire basket that was placed in the bottom of the autoclave.

A solution of sodium hydroxide or sodium carbonate (the mineralizer), with additives such as lithium salts, and deionized or distilled water was used to fill the vessel to 75% to 85% of its volume. The bottom half of the growing vessel was heated to temperatures averaging between 350°C to 400°C; the temperature of the top portion was maintained at 10°C to 50°C less. At these temperatures, the solution expands and creates an internal pressure in the vessel between 10,000 and 30,000 psi. Under these conditions the lascas dissolves to create a solution saturated with silica.

Through convection, the saturated solution transports dissolved silica to the cooler upper half of the vessel where it becomes supersaturated, and the excess dissolved quartz deposits on the seed crystals in the top half of the autoclave. The process continues until the growing crystals reach their desired size. The process normally takes 30 to 60 days, but at least one producer is making runs that are about 180 days.

The processing of quartz crystals for various end uses is the same whether natural or cultured crystal is used. Crystals are examined for physical defects before cutting. They are then cut, usually with diamond or slurry saws, along a predetermined crystallographic plane to a thickness slightly larger than that desired. Each wafer is inspected and diced into blanks of the desired dimensions. The blanks then progress through a series of lapping stages until they reach the final thickness; electrodes are attached and the crystals are mounted in suitable holders. The final assembly, called a quartz crystal unit, is ready for insertion into an electronic circuit.

The U.S. Bureau of Mines collected

domestic production and consumption data for quartz crystal through a voluntary survey of U.S. operations. Four of five companies responded to the canvass for the production of cultured quartz crystal, representing 100% of total production shown in table 1. Of the 28 operations canvassed concerning consumption of quartz crystal, 22 responded, 5 of which did not consume quartz crystal in 1994. These companies represented nearly 100% of total consumption, also shown in table 1. Consumption for the nonrespondent was estimated using reported prior-year consumption levels. *(See table 1.)*

Consumption

Consumption of lascas by the four domestic quartz crystal producers is shown in table 1. The 23 active device-fabricating companies in 9 States consumed quartz crystal in 1994. Of these companies, all but one consumed only cultured quartz crystal. The one company that used natural quartz used an extremely small amount.

Quartz crystal was used in piezoelectric and optical applications. The piezoelectric effect is achieved when a suitable electrical signal is applied to a quartz wafer or blank with appropriate electroding, and the wafer then vibrates mechanically throughout the bulk of the material at a characteristic natural resonance frequency. The quartz resonators are uniquely suitable for military-aerospace and commercial bandpass filter applications that require very high selectivity or in oscillator applications that require very high stability. In addition, for many applications requiring only moderate stability, a quartz resonator offers a unique combination of high performance, small size, and low cost. Quartz resonators were used for many less demanding applications such as providing timing signals for watches, clocks, and microprocessors in industrial, automotive, and consumer products.

The quartz wafer becomes too thin for practical use for very high frequencies (above 100 megahertz). Quartz crystal structures that use surface vibrations, in which the frequency is determined by electrode dimensions rather than wafer thickness, have become more important at these higher frequencies. These structures are called surface acoustical wave (SAW) devices. Most optical applications used quartz in the fused form as silica glass. Relatively small quantities of cultured quartz crystal were used directly for special optical considerations. Quartz's crystal properties are responsible for its uses that deal with normally polarized laser beams. Quartz retardation plates (especially quartz wave plates), Brewster windows and prisms, birefringent filters, and tuning elements are used in laser optics.

Historically, quartz crystal has been a material of strategic importance. During World War II, quartz was used principally in analog communications (e.g., in telephone multiplexing and in mobile military radios). Today, because of military emphasis on command, control, and communications surveillance and the growth of more sophisticated electronic systems, the importance of quartz crystal devices has grown. Many of the military applications are at the leading edge of technology. It has been U.S. Department of Defense policy to require that all military systems be hardened to nuclear radiation. To meet this special requirement, cultured quartz crystal must be radiation hardened by sweeping, a technique to remove certain impurities from the quartz.

Cultured quartz was used almost exclusively by the crystal device industry because of cost advantages. For resonator applications, raw quartz must be cut into thin wafers oriented precisely with the raw material crystal axes. The uniformity and convenience of cultured quartz have made its use almost universal. Unlike cultured quartz, natural electronic-grade quartz requires special orientation, cutting, grading, and sizing to produce a quartz wafer. As a result, most device manufacturers that cut natural quartz in the past have discontinued its use. One of the remaining uses of natural electronic-grade material was in pressure transducers used in deep wells.

Prices

The average value of as-grown cultured quartz was $60 per kilogram. The average value of lumbered quartz, as-grown quartz that has been processed by sawing and grinding, was about $300 per kilogram.

Foreign Trade

The Bureau of the Census began using the Harmonized Tariff Schedule in 1989 to identify material passing through U.S. customs. This system makes classification codes for imports and exports consistent internationally. With the adoption of the new codes, imports and export codes for quartz crystal changed, and some formerly listed details are no longer available. The import code for Brazilian crude pebble, which represented nearly all lascas imports recorded, was eliminated. Although this material probably continued to enter the United States, the new code system aggregated several categories making information about specific materials unavailable. Likewise, the export data for natural electronic-grade quartz crystal were no longer available.

World Review

Synthetic quartz crystal production is concentrated in the United States, Japan, and Russia with several companies producing crystal in each country. Smaller production capacity exists in Belgium, Brazil, Bulgaria, China, France, Germany, the Republic of South Africa, and the United Kingdom. Details concerning quartz operations in China, the Newly Independent States (formerly the U.S.S.R.), and other Eastern European countries are unavailable. However, it is known that the Newly Independent States have significant capacity to produce synthetic quartz.

Outlook

Domestic production of cultured quartz crystal has grown or remained relatively stable since 1986. Demand for crystal devices for electronic consumer products and microprocessor controlled devices should continue to grow and quartz crystal production should remain strong well into the future. Because crystal devices continued to be used in an increasing variety of applications from kitchen appliances to military hardware in addition to the traditional items such as watches, demand should continue to increase and additional production capacity may be required worldwide.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Quartz Crystal. Ch. in Mineral Commodity Summaries, annual.

Other Sources

Electronic News, weekly.
Electronics, biweekly.
Electronic Component News, monthly.
Industrial Minerals (London), monthly.
Mining Engineering, monthly.

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[1] National Materials Advisory Board. Quartz for the National Defense Stockpile. Natl. Acad. Sci., Washington, DC, NMAB-424, Jan. 1985, 99 pp.

[2] Work cited in footnote 1.

TABLE 1
SALIENT U.S. ELECTRONIC-AND OPTICAL-GRADE QUARTZ CRYSTAL STATISTICS

(Thousand kilograms and thousand dollars)

	1990	1991	1992	1993	1994
Production:					
Mine 1/	423	454	778	454	544
Cultured	441	441	407	394	294
Exports:					
Cultured 2/					
Quantity	39	53	15	24	38
Value 3/	$1,750	$2,620	$1,280	$2,260	$6,110
Consumption:					
Natural (electronic-and optical-grade)	(4/)	1	(4/)	(4/)	(4/)
Cultured (lumbered)	14	12	10	31	48
Cultured (as grown)	326	353	276	275	312
Total	340	366	386	306	360

1/ Excludes lascas produced for specimen and jewelry material uses.

2/ Bureau of the Census as adjusted by the U.S. Bureau of Mines.

3/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

4/ Less than 1/2 unit.

RARE EARTHS

By James B. Hedrick

The rare earths are a relatively abundant group of elements that range in crustal abundance from cerium, the 25th most abundant element of the common elements at 60 parts per million, to lutetium, the 61st most abundant element at 0.5 part per million. The rare earths were discovered in 1787 by Swedish Army Lieutenant Karl Axel Arrhenius when he collected the black mineral ytterbite (later renamed gadolinite) from a feldspar and quartz mine near the village of Ytterby, Sweden. With similar chemical structures, the rare-earth elements proved difficult to separate. It was not until 1794 that the first element, an impure yttrium oxide, was isolated from ytterbite by Finnish chemist Johann Gadolin. The rare earths are iron gray to silvery lustrous metals; typically soft, malleable, and ductile; and usually reactive, especially at elevated temperatures or when finely divided. Melting points range from 798° C for cerium, which at atmospheric pressure is denser as a liquid than as a solid, to 1,663° C for lutetium. The rare earths' unique properties are used in a wide variety of applications.

Domestic mine production of rare earths increased in 1994. The domestic economy rebounded strongly in 1994, and inflation rose a modest 2.1%. Estimated domestic apparent consumption increased 5%; with earnings by the major domestic processor reportedly increasing amid gains in sales. *(See table 1.)* Demand increased for rare earths used in petroleum fluid cracking catalysts, automotive catalytic converters, and permanent magnets, while phosphors for television, X-ray intensifying, and lighting remained stable. Yttrium was used primarily in lamp and cathode ray tube phosphors and in structural ceramics and oxygen sensors.

The domestic use of scandium in 1994 remained small. Commercial demand remained extremely small, with most metal and compounds sold for metallurgical research and analytical standards. Minor amounts were used in specialty lighting and semiconductors.

Legislation and Government Programs

The calendar year 1994 included the U.S. Government fiscal years for 1994 and 1995. Public Law 103-160, the National Defense Authorization Act for fiscal year 1994, was enacted on November 30, 1993, and covered the year 1994 through September 30. It continued specific previous authorizations for disposal of stocks in the National Defense Stockpile (NDS) classified as excess to goal. The National Defense Authorization Act for fiscal year 1995, Public Law 103-337, was enacted on October 5, 1994, and covered the last 3 months of 1994. Stocks of rare earths in sodium sulfate were all classified as excess to goal throughout 1994 and were inventoried at 457 metric tons.

U.S. tariff rates, specific to the rare earths, including scandium and yttrium, are unchanged for 1994, except for certain special tariff revisions for Canada and Mexico. Revisions to rare-earth tariffs for Canada and Mexico were the result of Presidential Proclamation 6641, implementing the North American Free Trade Agreement (NAFTA), effective January 1, 1994. Except for certain staged reductions for Canada and Mexico as designated under NAFTA, tariff rates for other foreign countries were negotiated under the Generalized Agreement on Tariffs and Trade (GATT) Uruguay Round of Multilateral Trade Negotiation. The GATT Uruguay Round of negotiations were completed in November 1994 with new staged rate schedules taking effect January 1, 1995. U.S. tariff rates for rare earths are listed in the Harmonized Tariff Schedule of the United States (1994), publication 2690, with supplement, and the Harmonized Tariff Schedule of the United States (1995), publication 2831, with a July supplement, as compiled by the United States International Trade Commission. Publication 2831 is available from the Government Printing Office under document number 949-011-00000-3.

Production

Domestic mine production data for rare earths are developed by the U.S. Bureau of Mines (USBM) from a voluntary survey of U.S. operations entitled, "Rare Earths, Thorium, and Scandium." The two mines to which a survey form was sent, responded, representing 100% of known mine production. Mine production data are withheld to avoid disclosing company proprietary data. Two domestic mines produced rare earths in 1994. The United States was the world's second largest producer of rare earths for the second consecutive year. Producers were Molycorp, Inc., a wholly owned subsidiary of Unocal Corp., and RGC (USA) Minerals Inc. Bastnasite was mined by open pit methods by Molycorp at Mountain Pass, CA. Molycorp's mine was the leading producer of rare earths in the United States and second in the rest of the world. According to company spokesperson, mine production increased from the previous year's level of 17,754 tons rare earth oxides (REO) to 20,664 tons REO in 1994.

RGC (USA) Minerals Inc. recovered monazite for its rare-earth content as a byproduct during processing for titanium and zirconium minerals. RGC (USA), a wholly owned subsidiary of the Australia-based Renison Goldfields Consolidated Ltd. (RGC), operated a dredging operation at Green Cove Springs, FL. Byproduct monazite production decreased 27% in 1994 as demand for thorium-bearing rare-earth ores declined.

Refined lanthanides were produced by three companies in 1994. Molycorp produced refined compounds from bastnasite at its separation plant at Mountain Pass, CA. Rhône-Poulenc Basic Chemicals Co. produced lanthanide compounds from rare-earth intermediate compounds at its facility at Freeport, TX, and Grace Davison (formerly Davison Specialty Chemical Co.) refined rare earths for fluid cracking catalysts from rare-earth chloride and other intermediate rare-earth compounds at

Chattanooga, TN.

Except for minor amounts of yttrium contained in monazite and other rare-earth minerals, essentially all yttrium was derived from imported compounds.

Three scandium processors operated in 1994. High-purity products were available in various grades with scandium oxide produced up to 99.999% purity. Sausville Chemical refined scandium concentrates at its facilities in Garfield, NJ, to produce scandium oxide, fluoride, nitrate, chloride, and acetate. Boulder Scientific Co. processed scandium at its Mead, CO, operations. Scandium concentrates were derived from a variety of ores. Boulder's main ore source was thortveitite-bearing tailings from the mined-out Crystal Mountain fluorite mine near Darby, MT. Scandium also was processed by APL Engineered Materials in Urbana, IL, to produce compounds and metal.

Reactive Metals and Alloys Corp. (REMACOR) was the principal domestic producer of mischmetal. Production of mischmetal, rare-earth silicide, and other rare-earth alloys decreased 25% in 1994. Production of high-purity metals also decreased.

Principal domestic producers of neodymium-iron-boron magnet alloys were the Delco Remy Div. of General Motors, Anderson, IN; Neomet Corp., West Pittsburg, PA; and Rhône-Poulenc Basic Chemicals, Phoenix, AZ. Leading U.S. producers of rare-earth magnets were: Delco Remy, Anderson, IN; Hitachi Magnetics, Edmore, MI; Crucible Materials, Elizabethtown, KY; and IG Technologies, Valparaiso, IN.

Consumption

Statistics on domestic thorium consumption are developed by surveying various processors and manufacturers, evaluating import-export data, and analyzing Government stockpile shipments. Domestic apparent consumption of rare earths increased 5% in 1994 compared with that of 1993. The producers of mischmetal, rare-earth silicide, and other rare-earth alloys produced 25% less rare earths in 1994 than they did in 1993, while consumption of the alloys decreased 66%. Shipments of the mixed rare-earth alloys declined 63%. Consumption of mixed rare-earth compounds showed a strong gain of 216% as demand continued to surge for mixed intermediates for petroleum fluid cracking catalysts and automotive catalytic converters. Domestic shipments of mixed compounds, which increased only 7% in 1993, caught up to demand in 1994 with a 285% increase.

The approximate distribution of rare earths by use, based on information supplied by primary processors and some consumers, was as follows: catalysts in petroleum refining, 34%; metallurgical uses as iron and steel additives and as alloys, 8%; glass polishing compounds, glass additives, and ceramics, 37%; permanent magnets, 14%; lighting, phosphors, mantles, research, and miscellaneous, 6%.

Yttrium consumption was estimated by the USBM commodity specialist at 344 metric tons for 1994. The approximate distribution of yttrium by end use, based on analysis of import data, was as follows: lamp and cathode ray tube (CRT) phosphors, 68%, structural ceramics and components, 29%, and oxygen sensors and miscellaneous, 3%. Yttrium compounds were sourced from China, 62.8%; the United Kingdom, 29.3%; Hong Kong, 4.75%; Japan, 2.18%; and France, 0.96%.

Stocks

U.S. Government stocks of rare earths in the NDS remained at 457 tons throughout 1994. Rare-earth stocks held in the stockpile were contained in sodium sulfate and were inventoried on a contained-REO basis. NDS stocks of rare earths are available for sale from the U.S. Department of Defense's Defense Logistics Agency.

Prices

Prices for rare earths were mixed in 1994. Domestic prices for lanthanide and yttrium oxides were unchanged from the 1993 levels, except for increases in cerium oxide. Prices for rare-earth chlorides increased in response to strong demand for thorium-free feed materials. Neodymium carbonate prices also increased as demand for neodymium-containing permanent magnets remained strong. All rare-earth prices remained nominal and subject to change without notice. Competitive pricing policies remained in effect with prices for most rare-earth products quoted on a daily basis.

Prices quoted by Molycorp for unleached, leached, and calcined bastnasite in standard quantities, containing 60%, 70%, and 85% REO, remained unchanged from the previous year's level of $2.87, $3.20, and $3.86 per kilogram ($1.30, $1.45, and $1.75 per pound) of contained REO, respectively.

The price range of Australian monazite (minimum 55% rare-earth oxide including thoria, f.o.b./f.i.d.),[1] as quoted in Australian dollars (A$), remained unchanged at A$300 to A$350 per ton at yearend 1994.[2] Changes in the United States-Australia foreign exchange rate in 1994, resulting from a weaker U.S. dollar on world markets, caused the U.S. dollar to be down $0.10 against the Australian dollar at yearend. Converted from Australian dollars, the U.S. price range for monazite increased significantly from US$204 to US$238[3] per ton in 1993 to US$233 to US$272[4] per ton in 1994.

The nominal price for basic neodymium-iron-boron alloy, compiled by the author from several U.S. producers, was $26.68 per kilogram ($12.10 per pound) at yearend, f.o.b. shipping point, 1,000-pound minimum. Most alloy was sold with additions of cobalt (up to 15%) or dysprosium (up to 5%). The cost of the additions was based on market pricing; with cobalt at $54.37 per kilogram (average $24.66 per pound) the cost would be about $0.54 for each percent addition per kilogram ($0.25 for each percent addition per pound).

The price for standard-grade domestic mischmetal remained unchanged from the previous year at $12.68 per kilogram. Market prices were stable at $9 to $13 per kilogram.

Rare-earth metal prices were mixed with yttrium and neodymium increasing slightly while dysprosium and samarium prices edged lower. Most other rare-earth metal prices were unchanged. High-purity rare-earth metals varied from $29 per kilogram for magnet grade neodymium to $24,000 per kilogram for distilled-grade lutetium.

Molycorp quoted prices for lanthanide (rare earth) and yttrium oxides, net 30 days, f.o.b. Mountain Pass, CA, in effect at yearend 1994, as shown in table 2.

Molycorp also quoted prices for lanthanide (rare earth) compounds, net 30 days, f.o.b. Mountain Pass, CA, in effect at yearend 1994 as shown in table 3.

Rhône-Poulenc quoted rare-earth prices, per kilogram, net 30 days, f.o.b. New

Brunswick, NJ, or duty paid at point of entry, in effect at yearend 1994, as shown in table 4.

No published prices for scandium oxide in kilogram quantities were available. Yearend 1994 nominal prices for scandium oxide per kilogram were compiled by the author from information from several domestic suppliers and processors. Prices increased slightly from the previous year for most grades and were listed as follows: 99% purity, $1,600; 99.9% purity, $3,300; 99.99% purity, $5,200; and 99.999% purity, $9,000.

Scandium metal prices, as listed by the Johnson Matthey Aesar Group, were as follows: 99.99% purity, lump, sublimed dendritic, ampouled under argon, $191.00 per gram; 99.9% purity, 250-micron powder, ampouled under argon, $559.00 per 2 grams; and 99.9% purity, lump, vacuum remelted, ampouled under argon, $257.00 per 2 grams; 99.9% purity, foil, 0.025 millimeters (mm) thick, ampouled under argon, 25 mm by 25 mm, $117.00 per item.[5]

Scandium compounds prices, as listed by Aldrich Chemical Co., were as follows: scandium acetate hydrate 99.9% purity, $37.00 per gram; scandium chloride hydrate $99.99% purity, $49.75 per gram; scandium nitrate hydrate 99.9% purity, $54.80; and scandium sulfate hydrate 99.9% purity, $56.65 per gram. Prices for standard solutions for calibrating analytical equipment, were $19.80 per 100 milliliter of scandium atomic absorption standard solution and $304.40 per 100 milliliter of scandium ICP/DCP standard solution.[6]

Prices for kilogram quantities of scandium metal in ingot form have historically averaged about twice the cost of the oxide while higher purity distilled scandium metal have averaged about five times the cost.[7]

Foreign Trade

Imports of rare earths increased in 1994. Imports gained 14% compared with 1993 and totaled 6,670 metric tons valued at $41 million. Exports of rare earths also increased in 1994. Domestic shipments of rare-earth materials climbed 41% to about 10,000 tons valued at $50 million.

World Review

Demand continued to increase for thorium-free rare-earth compounds for use as refinery feed material. China was a major source of rare-earth chlorides and nitrates. Demand for rare earths increased in Asia, Europe, and the United States as most world economies improved. *(See tables 8 and 9.)*

Australia.—The Mount Weld Rare-Earth project was not approved for further development.[8] According to Ashton Rare Earths Ltd.'s project manager, the project was halted until demand for cerium and world economic conditions improved. Markets for Mount Weld's principal commodity, cerium, improved in 1994, however, supplies of cerium remained adequate to meet demand in glass polishing, automotive catalytic converters, and glass additives. The Mount Weld project is scheduled for future periodic review as market conditions warrant.

Tioxide Group Ltd. (TGL), a wholly owned subsidiary of ICI, divested itself of its 44.5% holdings in Westralian Sands Ltd. (WSL).[9] The Japanese company, Ishihara Sangyo Kaisha Ltd. (ISK), also sold its 18.9% interest in WSL. Both TGL and ISK reportedly retained long-term contracts for the purchase of minerals sands from WSL, but decided to concentrate investments in other areas. WSL reopened its Yoganup Extended Mine in the first quarter of 1994 as markets for mineral sands improved. A new mineral sands concentrator was commissioned at the reopened mine in March to improve recovery rates.

Minproc Holdings, a 50% owner in the Tiwest mineral sands joint venture at Cooljarloo, Western Australia, changed its name to Ticor Ltd. The joint venture, which includes Kerr-McGee Corp.'s (U.S.) Australian subsidiary, KMCC Western Australia Pty. Ltd., produced heavy mineral sands near Cataby and operated a dry separation plant and synthetic rutile plant at Chandala. A Kerr-McGee's spokesperson said the Minproc name change would not affect its KMCC joint venture.[10]

Consolidated Rutile Ltd.'s (CRL), Gordon Mine on North Stradbroke Island suspended operation in March 1994 due to the sinking of its 3,000 ton per hour dredge.[11] The dredge was refloated at midyear and resumed operation. CRL's other mineral sands operation, the Bayside Mine in Queensland, continued to operate. CRL noted it had ceased recovery of monazite due to decreased world demand and problems in storing radioactive materials.

Cable Sands announced the opening of the Jangardup minerals sands operation in Western Australia.[12] The operation, located 60 kilometers south of Nannup in southern Western Australia, has a capacity to produce 230,000 tons of mineral sands per year.

BHP Ltd. continued to assess development of the Beenup mineral sands deposit.[13] Located in the Scott River area of Western Australia, the Beenup deposit would likely be mined by BHP's subsidiary Mineral Deposits Ltd. (MDL). MDL presently operates three mines in New South Wales.

Renison Goldfields Consolidated Ltd. operated four mineral sands mines in 1994. According to RGC's 1994 annual report, three mines were operated in Western Australia, the Eneabba West, Eneabba North, and Capel.[14] RGC's fourth mine produced mineral sands at Green Cove Springs, FL, in the United States. Except for the Eneabba North Mine operating at 75% of capacity, all other RGC mines reportedly operated at full capacity. With improvement in the world markets for mineral sand products, RGC is reassessing development of its principal undeveloped U.S. deposit, the Old Hickory in Virginia.

China.—China was the world's leading producer of rare earths in 1994, according to the China Rare Earth Information newsletter, producing 30,650 tons of REO.[15] Rare earth production in China, which was up 38.7%, was primarily from the Bayan Obo iron ore-rare earth mine in Nei Monggol Autonomous Region. Most ore from the deposit was processed and refined at facilities at Baotou, 135 kilometers to the south. Smaller quantities of bastnasite were produced in Shandong Province and at a new deposit at Sichuan Province.

Canadian-based Advanced Material Resources Ltd. (AMR) entered into another joint venture to produce rare earths from a bastnasite-bearing carbonatite at Mianning, Sichuan Province. AMR reportedly retained an 80% interest in the project which will have an initial capacity of 3,500 tons of REO per year. AMR's other interests in Chinese rare-earth processing plants are in Jiangyin, Jiangsu Province and Zibo, Shandong Province.[16]

France.—Rhône-Poulenc S.A. (RP) has switched feed materials for its La Rochelle separation plant from monazite to thorium-free intermediate rare-earth compounds. According to a U.S. spokesperson for the company, thorium waste generated during processing for the rare earths was previously sent to an approved disposal site in northern France until 1991. A 3 year extension of disposal privileges was extended to RP at a temporary storage facility through 1994.[17]

Malaysia.—The Far Eastern Economic Review reported that the joint venture Asian Rare Earth Sdn. Bhd. plant in Ipoh, Perak State, would close because of strong world competition, mainly from China.[18] The joint-venture operation was 35% owned by Mitsubishi Chemical Industries Ltd. of Japan.

Outlook

The shift towards higher purity mixed and separated products was evident in 1994, a trend that is expected to continue through the year 2010. A large increase in demand for rare-earth metals and alloys was noted for high-strength permanent magnets in 1994. Growth was also seen in individual and mixed rare-earth compounds as intermediate products for automotive catalytic converters, permanent magnets, ceramics, and phosphors for lighting and CRT's. Strong growth is expected to continue in the areas of permanent magnets, automobile catalytic converters, and rechargeable batteries.

World reserves are sufficient to meet world demand well into the 21st century. The fact that several large rare-earth deposits have yet to be developed coupled with the likelihood that new deposits will continue to be located, world resources should be adequate to fulfill demand for the foreseeable future.

Domestic companies have shifted away from radioactive-bearing rare-earth ores. This trend has had a negative impact on monazite-producing mineral sands operations worldwide. Future long-term demand for monazite in the rest-of-world, however, is expected to increase due to its abundant supply and low cost byproduct recovery. The cost and space to dispose of radioactive waste products in the United States is expected to continue to increase, severely limiting domestic use of monazite and other thorium-bearing ores.

Domestic demand in 1995 is expected to exhibit strong growth as the domestic economy shows signs of continued strength. World markets are expected to continue to be very competitive based on lower wages and fewer environmental and permitting requirements. Australia, China, and the United States are expected to remain significant rare-earth suppliers, while the future economic restructuring of Eastern Europe and Asia has a large potential for new sources.

The long-term outlook is for an increasingly competitive and diverse group of rare-earth suppliers. The economic base of the rare-earth industry has continued to broaden as the industry matures and diversifies.

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[1] Free-on-board/free into a container depot.

[2] Metal Bulletin (London). Non-ferrous Ores in Europe. No. 7744, Dec. 31, 1992, p. 25.

[3] Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.4725=US$1.00 based on yearend 1993 foreign exchange rates reported in the Wall Street Journal.

[4] Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.2878=US$1.00 based on yearend 1994 foreign exchange rates reported in the Wall Street Journal.

[5] ALPHA/AESAR 1994 Catalog. Available from AESAR/Johnson Matthey, P.O. Box 8247, Ward Hill, MA. p. 556.

[6] Aldrich Catalog Handbook of Fine Chemicals 1994-1995. Available from Aldrich Chem. Co., P.O. Box 14508, St. Louis, MO 63178-9916, p. 1244.

[7] Hedrick, J. B. Rare-Earth Metals. Ch. in Nonferrous Metal Prices in the United States through 1988. BuMines, 1990, pp. 81-98.

[8] Personal communication with Dudley J. Kingsnorth, Project manager, Ashton Rare Earths Ltd.

[9] Westralian Sands Limited. 1994 Annual Report.

[10] Personal communication with A. Barry Brandt, vice president of investor relations and communications, Kerr-McGee Corp.

[11] Personal communication with Consolidated Rutile Ltd. company representative.

[12] Min. J. (London). Jangardup Opened. V. 323, No. 8285, July 22, 1994, p. 59.

[13] Ind. Min. (London). Scott River Mineral Sands Interests. No. 265, Oct. 1994, p. 12.

[14] Renison Goldfields Consolidated Limited. 1994 Annual Report. 47 pp.

[15] China Rare Earth Information. China Rare Earth 1994. No. 37, May 1995, 4 pp.

[16] Ind. Min. (London). AMR Second Rare Earth JV. No. 316, Jan. 1994, p. 9.

[17] ———. RP Switches Rare Earth Ore. No. 319, Apr. 1994, pp. 15-16.

[18] Min. J. (London). Malaysian Rare Earth Plant to Close. v. 322, No. 8262, Feb. 11, 1994, p. 106.

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Westralian Sands annual report. (Australia)

TABLE 1
SALIENT U.S. RARE-EARTH STATISTICS 1/

(Metric tons of rare-earth oxides (REO) unless otherwise specified)

	1990	1991	1992	1993	1994
Production of rare-earth concentrates	22,700 2/	16,500 3/	20,700 3/	17,800 3/	20,700 3/
Exports:					
Cerium compounds	1,730	1,370	1,940	1,620	4,460
Rare-earth metals, scandium, and yttrium	241	71	44	194	329
Ores and concentrates	NA	459 4/	--	--	--
Rare-earth compounds, organic or inorganic	1,460	1,790	1,310	1,090	2,420
Ferrocerium and pyrophoric alloys	83	2,100	2,430	4,270	3,020
Imports for consumption: e/					
Monazite	440	--	--	--	--
Metals, alloys, oxides, compounds	4,490	6,110	5,330	6,670	7,620
Stocks, producers and processors, yearend	W	W	W	W	W
Consumption, apparent: e/	28,700	22,100	21,400	17,000	17,800
Prices, yearend, dollars per kilogram:					
Bastnasite concentrate, REO basis	2.87	2.87	2.87	2.87	2.87
Monazite concentrate, REO basis	1.19	0.93	0.41	0.40	0.46
Mischmetal, metal basis	11.02	11.02	12.68	12.68	12.68
Employment, mine and mill 5/	397	411	372	352	NA
Net import reliance 6/ as a percent of apparent consumption	20	25	33	(7/)	NA

e/ Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Comprises only the rare earths derived from bastnasite, as reported in Unocal Corp. annual reports.

3/ Comprises only the rare earths derived from bastnasite as obtained from Molycorp, Inc., company representative.

4/ Source: The Journal of Commerce Trade Information Service.

5/ Employment at a rare-earth mine in California and at a mineral sands operation in Florida, and a mineral sands tailings operation in New Jersey. The latter mines produced monazite as a byproduct and employees were not assigned to specific commodities.

6/ Imports minus exports plus adjustments for Government and industry stock changes.

7/ Net exporter.

TABLE 2
MOLYCORP RARE-EARTH OXIDE PRICES

Product (oxide)	Percent 1/ purity	Quantity (pounds)	Price per pound
Cerium (5310)	96.00	200.00	$7.90
Cerium (5350)	99.00	200.00	10.50
Dysprosium	96.00	50.00	60.00
Erbium	98.00	50.00	65.00
Europium	99.99	25.00	450.00
Gadolinium	99.99	55.00	55.00
Lanthanum	99.99	300.00	8.75
Neodymium (5400)	96.00	300.00	6.75
Neodymium (5410)	99.90	50.00	40.00
Praseodymium	96.00	300.00	16.80
Samarium	96.00	55.00	30.00
Terbium	99.90	44.10	375.00
Yttrium	99.99	50.00	52.50

1/ Purity expressed as percent of total REO.

TABLE 3
MOLYCORP RARE-EARTH COMPOUND PRICES

Product (compound)	Percent purity 1/	Quantity (pounds)	Price per pound 2/
Cerium carbonate	99.0	150	$9.75 3/
Cerium nitrate	96.0	300	2.90
Lanthanide chloride	46.0	250	1.25
Lanthanum carbonate	99.9	175	5.90
Lanthanum-lanthanide carbonate	60.0	150	2.15
Lanthanum-lanthanide chloride	46.0	250	1.05
Lanthanum-lanthanide nitrate	39.0	250	1.75
Neodymium carbonate	96.0	300	4.50

1/ Purity expressed in terms of REO equivalent.

2/ Priced on contained REO basis.

3/ Priced per pound CeO_2 basis.

TABLE 4
RHONE-POULENC RARE-EARTH OXIDE PRICES

Product (oxide)	Percent purity	Quantity (kilograms)	Price per kilogram
Cerium	99.50	25	$22.95
Cerium	99.95	25	37.80
Dysprosium	95.00	20	110.00
Erbium	96.00	20	190.00
Europium	99.99	10	990.00
Gadolinium	99.99	50	130.00
Holmium	99.90	10	485.00
Lanthanum	99.99	25	23.00
Lutetium	99.99	2	5,500.00
Neodymium	95.00	20	19.70
Praseodymium	96.00	20	36.80
Samarium	96.00	25	125.00
Terbium	99.90	5	685.00
Thulium	99.90	5	3,600.00
Ytterbium	99.00	10	230.00
Yttrium	99.99	50	88.00

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY 1/

Country	1993		1994	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cerium compounds, including oxides, hydroxides, nitrate, sulfate chloride, oxalate: (2846.10.0000)				
Austria	24,600	$262,000	28,000	$290,000
Belgium	7,900	59,000	12,000	43,700
China	669,000	2,850,000	718,000	3,150,000
France	281,000	2,670,000	879,000	7,590,000
Germany	2,310	62,800	8,940	204,000
India	128,000	168,000	60,600	67,300
Japan	148,000	3,860,000	173,000	4,010,000
Russia	2,310	7,670	91	1,350
United Kingdom	4,320	39,900	3,700	54,100
Other	1,410	37,300	7,220	19,700
Total	1,270,000	10,000,000	1,890,000	15,400,000
Rare earth compounds, including oxides, hydroxide, nitrate, and other compounds except chlorides: (2846.90.5000)				
Brazil	9,000	38,100	--	--
China	382,000	3,620,000	397,000	4,300,000
France	4,420,000	26,100,000	4,410,000	22,100,000
Germany	4,080	502,000	16,800	1,290,000
Hong Kong	--	--	45,100	640,000
Japan	145,000	8,200,000	190,000	8,940,000
Norway	731	140,000	19,700	3,420,000
Russia	3,960	362,000	6,610	154,000
United Kingdom	4,600	268,000	47,400	2,900,000
Other	7,480 r/	219,000 r/	6,410	618,000
Total	4,980,000	39,400,000	5,140,000	44,400,000
Mixtures of rare-earth oxide except cerium oxide: (2846.90.2010)				
Austria	4,460	179,000	7,680	363,000
Belgium	9,000	26,100	--	--
China	60,000	1,260,000	202,000	4,410,000
Estonia	9,040	26,700	--	--
France	71,100	4,810,000	51,800	3,120,000
Germany	6,900	837,000	9,600	149,000
India	28,900	92,900	--	--
Japan	38,200	1,930,000	9,470	994,000
United Kingdom	14,300	802,000	70,900	1,130,000
Other	7,670 r/	597,000 r/	3,200	147,000
Total	249,000	10,600,000	354,000	10,300,000
Rare-earth metals, whether intermixed or alloyed: (2805.30.0000)				
Brazil	20,400	142,000	29,900	197,000
China	161,000	1,550,000	169,000	2,230,000
Japan	1,230	140,000	3,880	127,000
Kazakhstan	--	--	16,400	74,900
Russia	3,280	113,000	14,100	74,400
United Kingdom	9,650	674,000	50,200	1,670,000
Other	360 r/	27,900 r/	620	83,000
Total	196,000	2,640,000	284,000	4,450,000

See footnotes at end of table.

TABLE 5-Continued

U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY 1/

Country	1993		1994	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Mixtures of rare-earth chlorides, except cerium chloride: (2846.90.2050)				
Belgium	--	--	24,000	$183,000
China	315,000	$4,150,000	317,000	4,020,000
France	1	8,000	7,670	101,000
India	1,900,000	1,580,000	1,840,000	1,560,000
Japan	24,000	1,360,000	77,200	3,190,000
Russia	7,210	61,200	16,000	288,000
Sweden	51,200	391,000	--	--
United Kingdom	56,200	427,000	132,000	1,920,000
Other	3,470 r/	115,000 r/	1,620	85,400
Total	2,360,000	8,090,000	2,410,000	11,400,000
Ferrocerium and other pyrophoric alloys: (3606.90.3000)				
Austria	15,800	292,000	8,140	195,000
Belgium	14,100	223,000	9,390	181,000
Brazil	34,800	450,000	23,200	294,000
France	50,200	612,000	36,000	489,000
Germany	3,200	66,400	--	--
Other	82 r/	10,100 r/	651	7,100
Total	118,000	1,650,000	77,400	1,170,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF RARE-EARTHS, BY COUNTRY 1/

Country	1993		1994	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cerium compounds: (2846.10.0000)				
Belgium	17,900	$87,800	34,700	$194,000
Brazil	84,300	430,000	133,000	542,000
Canada	385,000	3,440,000	516,000	4,700,000
France	40,000	423,000	33,100	186,000
Germany	64,600	589,000	38,400	247,000
Hong Kong	86,100	618,000	68,400	448,000
India	5,180	66,400	49,400	165,000
Italy	19,000	171,000	8,160	472,000
Japan	237,000	2,470,000	441,000	4,880,000
Korea, Republic of	211,000	1,420,000	1,480,000	5,350,000
Malaysia	467	87,000	51,000	616,000
Mexico	19,500	197,000	80,100	469,000
Netherlands	3,810	47,500	11,400	52,300
Singapore	229,000	834,000	771,000	3,100,000
South Africa, Republic of	7,170	37,700	3,380	53,800
Taiwan	141,000	542,000	650,000	2,330,000
Thailand	29,600	56,800	47,600	203,000
United Kingdom	6,290	39,400	23,900	159,000
Other	34,800 r/	163,000 r/	25,000	184,000
Total	1,620,000	11,700,000	4,460,000	24,400,000
Rare-earth compounds: (2846.90.0000)				
Bahamas, The	21,400	30,000	24,900	15,800
Belgium	791	231,000	163,000	184,000
Brazil	55,000	224,000	790,000	1,880,000
Canada	99,800	335,000	149,000	416,000
Chile	88,100	104,000	1,000	7,650
Finland	34,800	819,000	16,000	392,000
France	241,000	420,000	349,000	502,000
Germany	55,000	2,070,000	11,300	615,000
Hong Kong	5,690	232,000	57,300	115,000
Israel	--	--	19,500	44,900
Japan	366,000	5,780,000	212,000	2,950,000
Korea, Republic of	14,800	646,000	83,000	2,340,000
Panama	--	--	11,900	27,100
Phillipines	--	--	80,000	16,000
Taiwan	59,200	1,740,000	151,000	1,900,000
United Kingdom	26,100	379,000	277,000	745,000
Other	19,200 r/	1,120,000 r/	20,000	341,000
Total	1,090,000	14,100,000	2,420,000	12,500,000
Rare-earth metals, including scandium and yttrium: (2805.30.0000)				
Canada	39,300	283,000	52,800	325,000
China	14,000	58,300	--	--
Germany	65,300	131,000	86,300	75,300
Mexico	200	2,620	81,900	37,000
Taiwan	633	25,300	32,900	46,300
United Kingdom	25,000	124,000	11,300	449,000
Other	17,000 r/	1,770,000 r/	8,980	637,000
Total	161,000	2,400,000	274,000	1,570,000
Ferrocerium and other pyrophoric alloys: (3606.90.0000)				
Argentina	77,300	530,000	31,500	108,000
Australia	96,900	249,000	77,900	334,000
Bahrain	42,500	59,800	15,100	22,100
Barbados	44,100	48,300	30,900	32,800
Belgium	42,400	201,000	43,200	73,400
Brazil	41,800	80,200	1,210	35,500
Canada	378,000	1,880,000	581,000	2,130,000
China	110,000	130,000	1,480	34,200
Cyprus	26,900	35,500	40,800	42,600
Denmark	62,100	114,000	2,430	30,400
Dominican Republic	47,100	164,000	348	8,910
France	99,300	385,000	135,000	517,000
Gambia, The	113,000	1,580,000	--	--
Germany	284,000	826,000	500,000	984,000

See footnotes at the end of table.

TABLE 6--CONTINUED
U.S. EXPORTS OF RARE-EARTHS, BY COUNTRY 1/

Country	1993		1994	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Ferrocerium and other pyrophoric alloys--Continued: (3606.90.0000)				
Greece	124,000	$94,200	139,000	$139,000
Guatemala	137,000	166,000	2,640	8,980
Honduras	35,700	124,000	--	--
Hong Kong	437,000	931,000	266,000	621,000
Iceland	19,300	499,000	10,900	17,000
Indonesia	9,040	32,600	11,700	11,900
Ireland	21,000	48,700	16,000	13,300
Italy	4,120	34,200	11,100	227,000
Jamaica	96,300	123,000	73,000	118,000
Japan	696,000	4,440,000	164,000	2,100,000
Jordan	31,500	17,700	60,600	67,000
Korea, Republic of	5,000	22,000	20,200	314,000
Kuwait	61,000	111,000	38,400	54,600
Mexico	45,500	207,000	89,000	217,000
Netherlands	90,100	1,200,000	93,300	395,000
New Zealand	40,800	59,000	41,400	114,000
Peru	--	--	291,000	169,000
Portugal	--	--	14,200	20,000
Romania	31,300	132,000	--	--
Russia	381	66,900	6,980	160,000
Saudi Arabia	295,000	1,640,000	91,100	201,000
Singapore	358,000	1,280,000	119,000	331,000
Taiwan	119,000	587,000	27,600	115,000
Thailand	30,100	91,900	4,750	38,300
Trinidad and Tobago	29,200	42,600	4,410	11,600
United Arab Emirates	229,000	310,000	172,000	216,000
United Kingdom	255,000	923,000	55,300	192,000
Uruguay	634	14,600	90	10,000
Venezuela	16,900	36,500	1,220	54,300
Other	123,000 r/	861,000 r/	113,000	1,700,000
Total	4,810,000	20,400,000	3,400,000	12,000,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
MONAZITE CONCENTRATE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country 3/	1990	1991	1992	1993	1994 e/
Australia e/	11,000	7,000	6,000 r/	16,000 r/	6,000
Brazil	1,660	1,310	1,400	1,400 e/	1,400
China	2,380	1,190	1,800 e/	1,800 e/	1,800
India e/	4,500	4,000	4,000	4,600	4,600
Malaysia	3,320	1,980	777	407 r/	425 4/
South Africa, Republic of e/	1,320 4/	1,300	1,300	1,300	1,300
Sri Lanka e/	200	200	200	200	200
Thailand	377	400 e/	89	220 r/	200
United States	W	W	W	W	W
Zaire e/	124 4/	120	50	50	60
Total	24,900	17,500	15,600 r/	26,000 r/	16,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 23, 1995.

3/ In addition to the countries listed, Indonesia, North Korea, the Republic of Korea, Nigeria, and the former U.S.S.R. may produce monazite, but output, if any, is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels.

4/ Reported figure.

TABLE 8
RARE EARTHS: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of REO equivalent)

Country 3/	1990	1991	1992	1993	1994 e/
Australia e/	6,050	3,850	3,300 r/	8,800 r/	3,300
Brazil	911	719	396 r/	400 r/ e/	400
China e/	16,500	16,200	21,300	22,100	23,000
India e/	2,500	2,200	2,200	2,500	2,500
Malaysia	1,830	1,090	427	224	234 4/
Madagascar:					
Bastnasite	5	5	5	5 e/	5
Monazite	(5/)	(5/)	(5/)	(5/) e/	(4/)
South Africa, Republic of e/	724 4/	400 r/	400 r/	400 r/	400
Sri Lanka e/	110	110	110	110	120
Thailand	221	235	89 r/	220 r/	150
U.S.S.R. e/ 6/	8,500	8,500	8,000	7,000	6,000
United States 7/	22,700	16,500	20,700	17,800	20,700
Zaire e/	68	66	28	28	28
Total	60,100	49,800 r/	57,000 r/	59,500 r/	56,800

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data have been rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 30, 1995.

3/ In addition to the countries listed, rare-earth minerals are believed to be produced in Indonesia, North Korea, Mozambique, and Vietnam, but information is inadequate to formulate reliable estimates.

4/ Reported figure.

5/ Less than 1/2 unit.

6/ Dissolved in Dec. 1991; however, information is inadequate to formulate reliable estimates for individual countries.

7/ Comprises only the rare earths derived from bastnasite as reported in Unocal Corp. annual report, 1990 and from company sources.

RECYCLING—NONFERROUS METALS

By Gerald R. Smith

Introduction[1]

Recycling, a significant factor in the supply of many of the key metals used in our society, provides environmental benefits in terms of energy savings, reduced volumes of waste, and reduced emissions associated with the energy savings.

The estimated value of recycled nonferrous metals in 1994 was about $9.3 billion and is an increasingly important component of economic activity in the United States. Table 1 shows salient U.S. recycling statistics for selected metals. Table 1 also shows salient U.S. apparent supply and recycling statistics for selected metals.

As part of its Commodities and Materials Program, the U.S. Bureau of Mines (USBM) provides information and analysis on more than 100 raw and/or processed minerals. Collected data are assessed by commodity specialists, and information is disseminated to government, industry, and academia through consultative services and more than 100 recurring publications. This publication examines and reports on minerals and materials trends as well as environmental aspects of the entire life cycle of minerals use.

The USBM Research Directorate conducted research in 1994 on recycling of consumer products, advanced materials, copper processing waste, and metallurgical residues and effluents currently discarded. The Bureau also conducted research on impurity control during recycling and design for reuse or waste minimization. To increase the efficiency of recycling, the USBM investigated the control of impurities such as magnesium, zinc, and lithium in aluminum scrap and the removal of copper from ferrous scrap. The USBM also investigated methods to remove heavy-metal contaminants from mineral processing and manufacturing waste and to stabilize those heavy metals not removed.

Because of the increasing importance of recycling to domestic metal supply and the intense public interest, the USBM initiated this separate chapter on nonferrous metal recycling as part of its Annual Report series in 1991. A separate chapter on iron and steel scrap already had been part of this series for many years. The focus of this chapter is on aluminum, copper, lead, tin, and zinc recycling.

Aluminum[2]

Metal recovered from both new and old scrap reached an historic high of approximately 3.1 million tons in 1994, according to data derived by the USBM from its "Aluminum Scrap" survey. Of the 95 companies and/or plants to which monthly or annual survey requests were sent, 79 responded, representing 90% of the total scrap consumed shown in table 2.

According to figures released by the Aluminum Association Inc., the Can Manufacturers Institute, and the Institute of Scrap Recycling Industries Inc. a record 64.7 billion aluminum beverage cans were recycled in the United States during 1994. The recycling rate, based on the number of cans shipped during the year, was 65.4%, more than 2% higher than the 1993 recycling rate of 63.1%. According to the organizations' joint press release, every aluminum beverage can produced in 1994 had an average of 54.1% post-consumer recycled content, a far higher percentage than any other beverage container.

Imco Recycling Inc. announced plans to increase capacity at its used beverage can (UBC) recycling plant in Uhrichsville, OH. The $2.5-million expansion was expected to increase annual capacity at the plant by 25%, to 152,000 tons per year.[3] Imco also announced the purchase of Phoenix Smelting Corp., owner of Metal Resources Inc., which operated an aluminum recycling plant in Loudon, TN. The 54,000-ton-per-year recycling plant was near Imco's Rockwood, TN, facility.[4]

Alcan Aluminum Corp. announced plans to more than triple the UBC processing capacity at its Oswego, NY, aluminum rolling complex. Upon completion of the $23 million expansion project, the recycling unit reportedly would have the capacity to recycle 5 billion UBC's (75,000 tons) per year.[5] *(See tables 2, 3, and 4.)*

The London Metal Exchange (LME) reported that aluminum alloy ingot held at its U.S. warehouses at yearend 1994 increased to 1,100 tons, a slight increase from the 980 tons of alloy held at yearend 1993.

Prices.—Purchase prices for aluminum scrap, as quoted by American Metal Market (AMM), fluctuated during the year and closed the year at significantly higher levels than those at the beginning of the year. The yearend price ranges for selected types of aluminum scrap were as follows: mixed low copper-content aluminum clips, 69 to 70 cents per pound; old sheet and cast, 63 to 65 cents per pound; and clean, dry aluminum turnings, 64 to 65 cents per pound. Prices for aluminum UBC's also trended upward and closed at approximately twice the level of that at the beginning of the year. Aluminum producers' buying price range for processed and delivered UBC's, as quoted by AMM, began the year at 33 to 37 cents per pound. The price range at the end of the year narrowed and increased to 70 to 72 cents per pound.

The yearend indicator prices, as published by AMM, for selected secondary aluminum ingots also increased compared with those of the previous year and were as follows: alloy 380 (1% zinc content), 98.98 cents per pound; alloy 360 (0.6% copper content), 102.79 cents per pound; alloy 413 (0.6% copper content), 102.51 cents per pound; and alloy 319, 102.30 cents per pound. Metals Week published an annual average U.S. price of 74.71 cents per pound for A-380 alloy (3% zinc content). The average annual LME cash price for a similar aluminum 380 alloy was 65.90 cents per pound.

Foreign Trade.—Exports of aluminum scrap increased in 1994, reversing a 4-year downward trend. Japan continued to be the principal destination of exported scrap, accounting for almost 35% of the total.

Imports for consumption increased compared with those of the previous year. Canada remained the major shipping country to the United States, supplying 55% of the total aluminum scrap imports in 1994. *(See tables 5 and 6.)*

World Review.—According to preliminary estimates published by the World Bureau of Metal Statistics in June 1995, world production of secondary aluminum increased to 6.3 million tons in 1994 from the revised 1993 production figure of 6.1 million tons.

According to Aluminum Can Recycling Europe, 69,700 tons of aluminum UBC's were recycled in Europe, representing a recycling rate of 30%. The four countries with the highest individual recycling rates were Sweden (90%), Switzerland (83%), Iceland (80%), and Austria (65%).[6]

The recycling rate for aluminum UBC's in Japan increased to 61.1% in fiscal year 1994 from 57.7% the previous year, according to the Japan Aluminum Can Recycling Association. The association estimated that 9.07 billion cans were recycled compared with 6.8 billion cans in fiscal year 1993.[7]

Outlook

The domestic and world secondary aluminum industries are expected to continue to expand. The growth in the use of aluminum beverage containers is continuing and helping to expand the aluminum recycling industry around the world. Increased use of cast aluminum by the automotive industry, a major market for secondary aluminum ingot, is also encouraging the expansion of the secondary aluminum industry. Growing markets and the increased sensitivity of the public to the issue of waste management have combined to foster the development and expansion of aluminum recycling around the world.

Copper and Copper Alloy Scrap[8]

Annual Review

World production of secondary refined copper fell by about 100,000 tons to 1.8 million tons in 1994, and accounted for about 16% of global refined production. The United States accounted for most of the decline in secondary refined production. Following 6 years of surplus production and a near tripling of world refined inventories to 1.4 million tons, copper demand in 1994 exceeded production and global copper inventories declined by 360,000 tons. Refined copper prices, which in November 1993 had fallen to their lowest level in 7 years, rose during 1994 in response to increasing supply tightness. The U.S. producer price for refined copper averaged $1.41 per pound in December, up from $0.92 in December 1993.

Domestic consumption of refined copper rose by more than 13% during 1994 to record high levels. This was the third consecutive year of large demand increases, consumption having risen by 6.3% and 8.5%, respectively, in 1992 and 1993. In 1994, copper recovered from all old and new refined or remelted scrap comprised 38% of total U.S. copper supply and had an equivalent refined value of $3.3 billion. *(See tables 7 through 13.)* Conversion of old scrap to alloys and refined copper declined by 43,000 tons, but contributed 500,000 tons of copper to the market, a quantity equivalent to about 18% of U.S. apparent consumption. Purchased new scrap, derived from copper fabricating operations, yielded 827,000 tons of copper, up almost 80,000 tons from that of the previous year, and accounted for 62% of copper recovered from all scrap. This large increase in new scrap consumption reflects the increased domestic consumption of mill products, which, according to the Copper Development Association Inc., rose by almost 13% in 1994. About 77% of the copper contained in new scrap was consumed at brass mills. During the year, 8 primary and 5 secondary smelters, 9 electrolytic and 6 fire refineries, and 15 electrowinning plants operated in the United States. Three of the electrolytic refineries were dedicated facilities associated with secondary smelters and mostly processed anode derived from scrap; several other refineries that mainly processed primary anode purchased or tolled some anode derived from scrap. All the fire refineries processed copper scrap. Copper was consumed, both as refined copper and as direct melt scrap, at about 35 brass mills, 15 wire rod mills, and 600 foundries, chemical plants, and miscellaneous consumers. Of the total copper recovered from copper-, aluminum-, nickel-, and zinc-based scrap, copper smelters and refiners recovered 30%; brass mills, 51%; brass and bronze ingot makers, 10%; and miscellaneous manufacturers, foundries, and chemical plants, 9%. Unalloyed scrap accounted for 51% of copperbased scrap consumed, as shown on table 11.

While total smelter capacity remained unchanged at 1.9 million tons, investments made in 1993 and 1994 led to higher capacity usage and increased primary smelter production. Secondary smelter production however, declined slightly, and at yearend, Southwire Co. announced the immediate closure of its secondary smelter and the phase-out of the associated electrolytic refinery at its Gaston Copper Recycling Corp., Gaston, SC. High operating costs and the large additional capital investment needed to comply with environmental regulations were cited by the company as the reason for closure.

Prices.—Copper scrap prices trended upward in 1994, following the rise in refined copper prices. However, while the average producer price for refined copper rose about 53 cents per pound from January to December, the price rise for No. 2 scrap was only 32 cents per pound. Thus, the margin between the two materials widened from 18 cents per pound in January, to 39 cents per pound in December. While copper scrap prices correlate to the price of refined copper, the price paid for scrap at each level of processing must be sufficiently discounted to allow for all subsequent processing costs. Thus, a scrap collector who must perform such functions as sorting, shipping, chopping, baling, etc. will pay less for scrap than does the consumer of the scrap. Because of these inherent costs associated with the initial collection and processing of scrap, low refined copper prices, such as those experienced in January, squeeze processing and profit margins and reduce the quantity of scrap that can be recovered economically. Despite the increase in margins, consumption of No. 2 scrap, as well as lower grades of scrap consumed predominantly by secondary smelters, declined in 1994. Environmental and capacity constraints, along with constraints on materials availability, prevented secondary smelters from increasing throughput. As noted above, the Gaston smelter closed at yearend. Also, intense competition from exporters may have limited the availability of certain scrap types. This is also reflected in the decline of old scrap consumption; secondary smelters are the largest consumers of old scrap. On the other hand, consumption of No. 1 scrap and new scrap both increased, owing to high production levels at brass mills; brass mills are the principal consumers of No. 1 scrap and new scrap. Consumption of brass ingot, a product of brass scrap, also increased, owing to a rise in domestic casting production.

Foreign Trade.—Exports of both alloyed and unalloyed scrap rose significantly in 1994, while imports of copper alloy scrap declined markedly. Consequently, net exports of scrap rose to more than 250,000 tons, up from about 100,000 tons in 1993. The United States was one of the largest international sources for copper scrap, followed by France, Germany, and the United Kingdom. U.S. exports of copper scrap have been increasing since the 1960's, when the Asian nations began to industrialize. In 1994, China, Hong Kong, Japan, Korea, Singapore, and Taiwan, combined, accounted for 44% and 49%, respectively, of U.S. unalloyed and alloyed scrap exports. Exports of unalloyed scrap to Canada rose by more than 70%. Canada and Mexico were the leading sources for U.S. imports of copper and copper alloy scrap and accounted for 73% of imports in 1994. *(See tables 15 and 16.)*

Outlook

Over the next decade, new copper scrap will continue to be a premium material for the U.S. semifabricating industry, and its level of availability and the quantity recycled will be closely tied to the overall level of copper fabrication. The recovery of copper from old scrap declined in 1994 for the second consecutive year, and did not share in the strong growth in copper demand. Old scrap as a percentage of apparent consumption declined from 25% in 1991, to 19% in 1994. With the closure of the Gaston smelter, domestic recovery of copper from old scrap is expected to remain at or below the current level. However, if it is assumed that most copper scrap exports were old scrap destined for recovery, the total quantity of domestic source copper in old scrap recycled in 1994 increased by about 30,000 tons. Be-cause scrap is usually a lower-cost alternative to primary metal, it will continue to be of great interest to Far Eastern countries as they expand their industries. The recovery of copper (old scrap) from the large and growing reservoir of copper products in use may be limited by the following factors: (1) copper prices, (2) life of products, (3) available recovery technologies, (4) changing end-use patterns (5) and environmental regulation. Regulations to limit the lead content of plumbing fixtures in potable water distribution systems could result in the land-filling of high-leaded brass scrap, absent new recovery technologies; leaded brass scrap is the prime feed material to the ingot-making and foundry industries. The Basel Convention, an international agreement on the transboundry movement of hazardous waste, could impede the international flow of copper scrap.

Lead[9]

Refined lead is a soft, heavy metal, one of the first metals used by humankind. Among the important characteristics of lead are its electrochemical energy storage capability, its good corrosion resistance, and its low melting point, the latter making it relatively easy to cast. The United States is the world's largest producer and consumer of refined lead; domestic demand for lead is surpassed only by that for aluminum, copper, and iron.

Legislation and Government Programs.—The Lead Exposure Reduction Act was passed by the U.S. Senate at the end of May 1994. Included in this legislation was the establishment of a mandatory recycling program that prohibits incineration and landfill disposal of used lead-acid batteries and creates a distribution system whereby the used batteries are returned by the retailers to the secondary lead smelters for recycling. The U.S. House of Representatives did not advance its version of this legislation during 1994.

The Lead-Based Paint Hazard Trust Fund Act introduced in the 1st session of the 103d Congress by 7 cosponsors on June 22, 1993, gained 36 additional sponsors in the U.S. House of Representatives by the end of the 2d session of the 103d Congress, but no further action was taken on the bill during 1994. Essentially, the bill proposes a unitary tax of 45 cents per pound on all primary and secondary lead produced domestically and imported. This tax is intended to provide a dedicated revenue of $1-billion-per-year for use in the cleanup of lead-based paint hazards in accordance with Title 10 of the Housing and Community Development Act of 1992.

Consumption.—Domesticdemandpatterns for lead have undergone significant change in recent years as a result of human health concerns related to lead exposure and subsequent Government actions taken to reduce that exposure. In 1972, dissipative uses of lead, particularly in gasoline additives, pigments, ammunition, and chemicals, coupled with other uses where the potential for human exposure exists, such as in packaging, solders, plumbing, and certain other construction materials, amounted to about 510,000 tons, or 38% of the reported consumption of lead. In 1985, these end uses represented 205,000 tons, 18% of consumption, and in 1994 were only 140,000 tons, 10% of consumption. Lead consumed in lead-acid storage batteries grew accordingly during these years from 660,000 tons, 49% of lead consumption in 1972, to 840,000 tons, 73% in 1985, to 1.22 million tons, 84% in 1994. Consequently, the number of used batteries available for recycling also grew during this period. By 1994, the gross weight of lead-containing battery scrap processed at secondary smelters reached 1.01 million tons. According to the most recent Battery Council International statistics, the leadacid battery recycling rate in the United States was about 93% in 1993. *(See table 17.)*

Production.—In 1994, about 816,000 tons of lead were produced at secondary smelters from used lead-acid batteries. This was approximately 89% of the refined lead recovered from both old and new scrap, and 72% of the total production of refined lead from primary and secondary sources. The estimated value of the lead recovered from secondary sources in 1994 was $748 million. Domestic secondary production of lead increased by about 2% in 1994, returning to near the level reached in 1992. *(See tables 1, 18, and 19.)*

Domestic data for secondary lead consumption and production are developed by the USBM from a voluntary survey that includes data from both monthly and annual respondents. In 1994, secondary smelting and/or consuming companies which were sent a survey request numbered 174, of which 139 responded, providing 88% of the total reported U.S. lead consumption. Of the 24 companies producing secondary lead to which a survey request was sent, exclusive of those recycling copper-base alloys, 21 responded, providing 91% of the total refinery production of secondary lead. Data for the nonrespondents was estimated using prior year levels adjusted for general industry trends.

In U.S. secondary lead industry actions during 1994, GNB Battery Technologies Inc., Atlanta, GA, received approval from the Georgia Environmental Protection Agency to build and operate a new and expanded lead-acid battery recycling facility at its present Columbus, GA, location. The new secondary smelter/refinery, expected to be completed in mid-1995, will have a production capacity of 90,000 tons per year of lead, 4.5 times that of the existing plant at the Columbus site. GNB also acquired Quenell Enterprises, a Los Angeles-based lead oxide producer, in October 1994. This purchase reportedly was intended to further support GNB's growing in-house demands in battery production, recycling, and distribution associated with the opening of the new Columbus plant. GNB's plans to build a Greenfield secondary lead smelter in Waynesboro, GA, continued to be suspended indefinitely.

In September 1994, RSR Corp., Dallas, TX, suspended the process of obtaining permits for its planned $60 million battery recycling plant in Aiken County, SC. The suspension of such activity was made at the request of the Aiken County Economic Development Partnership, pending the outcome of a Federal grand jury indictment alleging environmental violations at RSR's Indianapolis, IN, recycling plant.

Foreign Trade.—Exports of lead scrap in 1994 were about 88,000 tons, nearly 63% higher than in 1993, and were valued at approximately $24 million, about 69% greater than in 1993. Canada and the Republic of Korea received 78% and 11%, respectively, of the exports of lead scrap. Imports of lead scrap for the year totaled 144 tons worth $80,000. *(See table 20.)*

Outlook

After 2 years of increases in lead demand in the United States, owing mainly to the increased use of lead acid batteries as both original equipment and replacement batteries in the automotive industry, consumption of lead is expected to decline slightly in 1995.

The rate of economic growth domestically is anticipated to be somewhat slower in 1995, but the automotive manufacturing sector will remain relatively strong, resulting in a higher demand for original equipment batteries. Total new vehicle production is estimated to increase by 5.7%, to 12.9 million units in 1995. This demand increase, however, will be tempered by a decrease in demand for replacement batteries, following a fairly mild 1994-95 winter nationwide. The net result is a predicted moderate decrease of about 2% in overall lead consumption during 1995.

Lead supply from domestic secondary and primary smelter production is expected to show a net decline of about 1% in 1995. While primary production should increase by about 4%, as a result of continued higher production at some of the larger operations, this increase will be countered by a decline in secondary production, a result of a modest shortage of available scrap.

Tin[10]

Tin was one of the earliest metals known to humankind. Tin occurs in nature principally as the oxide mineral cassiterite. Tin metal is commonly used as a protective coating or as an alloying metal with one or more other metals. Refined metal in the form of ingots is generally used as the starting point for most uses of tin. The major uses for tin are as follows: cans and containers, 32%; electrical, 22%; construction, 10%; and transportation, 11%; other uses account for the remaining 25%. Tinplating generally uses no scrap tin, but most other end-use items, especially solder and brass/bronze, use substantial quantities of tin scrap.

About 25% of the domestic supply of tin metal is metal recovered from scrap. In 1994, 10,893 tons of tin metal valued at an estimated $89 million was recovered from new and old tin scrap.

Old tin scrap is collected at hundreds of domestic scrap yards, at nine detinning plants, and at most municipal collection/recycling centers. New tin scrap is generated mainly in the tin mills at six steel plants, scores of canmaking facilities, numerous brass and bronze plants, and many solder making plants.

Detinning facilities are unique to the tin scrap industry, in that no other major metal industry has such large-scale facilities to remove plated metal. There are nine domestic detinning plants scattered across the country. Until about 1989, they processed almost entirely new tinplate scrap that originated in the tin mills of steel plants and canmaking plants. Since 1989, with new technology that shreds used tin cans, some of the detinning facilities have the capability of also detinning old tin cans. Only in the detinning process does free tin metal see its way to the marketplace. All the alloy forms of tin are recycled within their own product line industries and thus reappear as regenerated alloys. *(See tables 21, and 22.)*

Most tin scrap processing facilities are close to the tin-using industries and to densely populated areas. Most are in the Midwest and Northeast.

Domestic scrap data for tin are developed by the USBM from a voluntary survey of the U.S. tin scrap industry. The smaller side of this industry is covered by a canvass sent to five detinning companies monthly; all five responded or are estimated for. The larger side of the tin scrap industry, involving the alloys of tin, is covered largely by a canvass of the copper and lead scrap industries (tin's major coalloys) from which estimates are made for the tin content.

The former Steel Can Recycling Institute (SCRI) completed its first full year under its new name, the Steel Recycling Institute (SRI). The name change reflected a broadening of its mission to encompass not only steel cans (which had been its sole focus since its 1988 founding), but all steel products ranging from appliances to filing cabinets to cars. Since SCRI's inception in 1988, the steel can recycling rate had grown from 15% to 53% in 1994. The overall steel recycling rate has been over 60% for more than 20 years and currently stands at 66%.

The SRI announced several recycling highlights for 1994: a) Steel can recycling rates in the United States reached an all-time high of 53%, with more than 17.6 billion cans, weighing 1.5 million tons, recycled. b) Utilization of used steel cans as a scrap charge continued to increase. Steel mills and foundries were remelting about 500 steel cans every second. c) Each year, more than 30 billion steel cans are produced, packaging a variety of products from food and beverages, to paints, chemicals and personal care products. d) Nine out of 10 aerosol cans are made of steel and are recyclable when empty. More than 1,700 communities currently recycle aerosol cans. e) More than 170 million Americans have convenient access to steel can recycling through curbside, drop-off and buyback programs, as well as through magnetic separation at resource facilities. f)

The SRI's goal is to achieve a 66% recycling rate for steel cans by the end of 1995. g) The average American uses 144 steel cans each year. If every American recycled at least 95 steel cans in 1995, the goal of a 66% steel can recycling rate could be achieved.

The SRI continued to focus its attention on the recycling of aerosol steel cans. Some have felt that aerosol steel cans can be hazardous to recycle, but the SRI has maintained that as long as each can is first emptied it is no more hazardous to recycle than any other type of can. The SRI pointed to an especially successful aerosol steel can recycling program it coordinated in the State of Michigan. SRI claimed that over 1,500 communities are now recycling aerosol cans, including large cities such as Philadelphia, PA, and Washington, DC.

The Journal of Metals (February 1994) reported on studies conducted by the U.S. Bureau of Mines Rolla (MO) Research Center on characteristics of recycled automotive oil filters, many of which are made from tinplate. Increasingly, in recent years, used oil filters have become a steel scrap item used as an electric furnace scrap charge by steel minimills. TAMCO Steel Co., Rancho Cucamonga, CA, and Bayou Steel Co., LaPlace, LA, have been prominent in such scrap usage. The USBM research showed that crushed and drained oil filters have a bulk density that is higher than many traditional scrap steel grades, a chemical analysis low in residual elements (except tin), and an overall yield of oil-filter scrap to cast steel of 76% to 85% depending on the method used to prepare the scrap.

One of the major domestic detinners, Proler International Corp., announced plans to expand its capacity to recycle tin-bearing solutions from the electronics industry at its Coolidge, AZ, facility. Proler announced that the company developed its own process to extract tin from solutions and sludges by adapting detinning technology used internally. Proler produces tin anodes from these solutions and sludges, which it sells back to the electronics industry. Proler felt the need to expand because demand for the service exceeded capacity at its existing plant. Arizona is the home of numerous electronics plants.

World Review.—The United States, France, Germany, Japan, and the United Kingdom, generally lead the world in tin recycling activity and innovation. Environmental pressures in those countries for the past 20 years have acted as a powerful incentive.

In contrast to the United States and Europe, where detinning has long been a substantial activity, Japanese industry does little or no detinning because it feels that the tin coating on tinplate has become so thin in the past 20 years that detinning is not economical.

Outlook

The near- and long-term outlook for tin recycling is positive, with modest growth expected, about 1% annually. Tin is a high-value industrial material. In the form of tinplate, one of its main uses, it is easily separated magnetically for recycling. Tin consumption is expected to grow about 1% annually. Scrap is expected to grow from 25% of total metal consumed in 1994 to 27% annually by the year 2000. A major incentive is expected to be environmental legislation, mostly at the local and State level. If tin prices remain relatively high compared with prices of other major metals, the industry will have sufficient incentive to recycle this costly metal.

Zinc[11]

Zinc is the fourth most widely used metal after iron, aluminum, and copper. About three-fourths is in metal form and one-fourth in compound form. More than 90% of the metal is used for galvanizing steel and for alloys; the remainder is used to produce dust, oxide, and various chemicals. Most metal products find widespread use in the automotive, construction, electrical, and machinery sectors of the economy. Compounds similarly are dispersed in distribution and use, but are mainly used in agricultural, chemical, paint, pharmaceutical, and rubber sectors of the economy.

Nearly one-third of the 1.42 million tons of zinc consumed annually by domestic industries is secondary zinc. In 1994, about 367 tons of secondary zinc, valued at about $390 million, was recovered in refined metal, alloys, dusts, and chemicals. Scrap containing about 58,300 tons of zinc and valued at $34.4 million was exported in 1994, whereas 51,700 tons of zinc in scrap, valued at $19.8 million, was imported.

Recycled zinc was derived 70% from new scrap and 30% from old scrap. New zinc scrap was generated mainly in galvanizing and diecasting plants, brass mills, and manufacturing facilities where basic zinc materials were consumed. New scrap consisted mostly of drosses, skims, furnace dusts, and residues (from galvanizing and diecasting operations, brass mills, and chemical plants) and clippings from the processing (stamping, trimming, etc.) of galvanized steel sheet and strip, rolled zinc, and brass sheet. Old scrap consisted almost entirely of diecastings, (mainly from scrapped automobiles), brass products, and rolled zinc items, such as gutters, roofing, and engraving plates. Zinc recovery from the burning of tires for energy is small but growing, whereas recovery from both old and new galvanized steel scrap has increased dramatically. Old zinc and brass scrap were collected at hundreds of domestic scrap yards, at more than 200 U.S. automobile and appliance shredding operations, and at numerous municipal collection centers. In 1994, there were three primary and seven secondary smelters that processed scrap, drosses, skims, and/or steelworking electric arc furnace (EAF) dust into slab zinc, zinc alloys, and zinc dust. Seven other plants processed skims, drosses, scrap, and residues into zinc sulfate and/or chloride chemicals. Secondary brass and bronze were recycled at more than 500 secondary smelters, foundries, and ingot makers. Eagle Zinc, Hillsboro, IL, produced American-process zinc oxide from oxidic secondary materials. Most secondary zinc plants are in the Eastern and Midwestern United States; the ZCA plant in Monaca, PA, is, by far, the single largest processor secondary zinc. Crude zinc concentrates extracted from EAF dust were produced at four plants. *(See tables 23, 24, and 25.)*

Because of wide differences in the character and content of zinc-bearing scrap, zinc recycling processes vary widely. Zinc-containing metals generally are separated from other materials initially by physical means such as magnetic separation, sink-floating, and hand sorting. In the case of mixed nonferrous metal shredder scrap, zinc can be separated from higher-melting point metals, such as aluminum and copper, by selective melting in a sweat furnace. Zinc in galvanized scrap is largely recovered in furnace dust when the scrap is charged into a steelmaking furnace; however one commercial process has been developed to strip zinc from galvanized scrap with a caustic leach prior to recycling the substrate steel to the steelmaking process.

Clean new scrap, mainly brass and rolled zinc clippings and reject diecastings, generally only require remelting before reuse. Drosses, fragmentized diecastings, and mixed high-grade scrap typically are remelted, followed by zinc distillation with recovery as metal, dust, or oxide. Sometimes, high-purity drosses are simply melted and reacted with various fluxes to release the metallic content; often the recovered metal can be used directly as a galvanizing brightener or master alloy. Medium- and low-grade skims, oxidic dust, ash, and residues generally undergo an intermediate reduction-distillation-pyrometallurgical step to upgrade the zinc product before treatment or they are leached with acid, alkaline, or ammoniacal solutions to extract zinc, which is subsequently recovered as a compound by precipitation-crystallization or as a salable chemical retained in solution. Almost all of the zinc in EAF dusts is first recovered in an upgraded, impure zinc oxide product; however, several commercial EAF-dust-treatment plants are able to bypass the intermediate step and recover zinc metal directly. The upgraded zinc oxide pyrometallurgical production is almost always shipped to a primary pyrometallurgical zinc smelter for refinement to metal. For the most part, the zinc metals, alloys, dust, and chemicals recovered from secondary materials are comparable in quality to those derived from primary materials.

Recovery efficiency is very high from simple remelting, but declines as the number of processing steps increases and, generally, as the zinc content of the scrap declines. Zinc recovery from most secondary processes ranges between 40% and 85%; however, oxide materials, slags, and residues resulting from initial processes may, in turn, be recycled, resulting in further zinc recovery.

Zinc materials made from zinc-base scrap are slab zinc, alloys, dusts, and compounds. Brass scrap, on the other hand, typically is remelted and, with alloy adjustment, recast as brass. Zinc chloride and sulfate compounds are produced largely by acid leaching of zinc skims, drosses, and chemical residues. Impure zinc oxide products and zinc-bearing slags are sometimes used as trace element additives in fertilizers and animal feeds. Zinc in brass is the principal form of secondary recovery, although in the past few years, production of secondary slab zinc has risen substantially because it has been the principal zinc product of EAF dust recycling.

Prices.—Prices paid for scrap and secondary materials are negotiated, often on the basis of a daily or average LME price for zinc metal. Bids are required for U.S. Department of Defense scrap sales. Prices depend on factors such as geographic location, quantity available, quality, grade, the presence of other components or elements, and environmental difficulties in handling, transporting, or treating. In the case of EAF dust, the dust generator usually pays the dust processor a fee to recycle the material. Typically, there is a basic charge for dust with 20% zinc content; generators of dust with lower zinc content pay more, whereas generators of dust with higher zinc content pay less. Zinc and brass scrap prices are generally not available, although average daily, weekly, or monthly prices for a few specific common types are published in American Metal Market, Metal Bulletin, and Metal Bulletin Monthly.

Outlook

Driven by public concern for the environment and legislation intended to protect the environment, domestic and world secondary zinc recovery is expected to increase as a percentage of zinc consumption in the next decade. However, the prospect for recovery equivalent to more than 35% to 40% of consumption is relatively poor because of the dissipative nature and diversity of zinc uses. Greater recovery of zinc from galvanized steel scrap can be expected in the future as several processes for dezincing galvanized scrap have been developed and tested. Increased processing of low-zinc EAF dust, from other steelmaking processes, and zinc residues from energy-generating tire burning appear to be other sources for near term gains in secondary zinc output. Increased zinc recovery from the recycling of carbon-zinc and alkaline batteries and municipal incinerator dusts and residues are longer term possibilities. Secondary zinc recycling could rise dramatically in the next decade if the powering of a substantial number of electric cars by zinc-air batteries become a reality.

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[1] Prepared by J. F. Papp, physical scientist, Branch of Metals.

[2] Prepared by P. Plunkert, physical scientist, Branch of Metals.

[3] American Metal Market. Imco to Raise Capacity 25% at Ohio UBC Plant. V. 102, No. 86, May 5, 1994, p. 7.

[4] Metal Bulletin Monthly. Imco Recycling. V. 288, Dec. 1994, p. 80.

[5] American Metal Market. Alcan to Triple UBCs at Oswego. V. 102, No. 87, May 6, 1994, p. 2.

[6] ———. 1994 European Beverage Can Consumption. V. 103, No. 115, June 15, 1995, p. 5.

[7] ———. Japanese UBC Recycling Rate Up. V. 103, No. 139, July 21, 1995, p. 10.

[8] Prepared by D. L. Edelstein, physical scientist, Branch of Metals.

[9] Prepared by G. R. Smith, physical scientist, Branch of Metals.

[10] Prepared by J. F. Carlin, Jr., physical scientist, Branch of Metals.

[11] Prepared by S. M. Jasinski, physical scientist, Branch of Metals.

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TABLE 1
SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS 1/

Year	Quantity (metric tons)				Percent recycled	Value (thousand dollars)			
	New scrap 2/	Old scrap 3/	Recycled metal 4/	Apparent supply 5/		New scrap	Old scrap	Recycled metal	Apparent supply 6/
ALUMINUM 7/									
1990	1,030,000	1,360,000	2,390,000	6,300,000	38	$1,690,000	$2,220,000	$3,910,000	$10,300,000
1991	969,000	1,320,000	2,290,000	6,010,000	38	1,270,000	1,730,000	3,000,000	7,880,000
1992	1,140,000	1,610,000	2,760,000	6,870,000	40	1,450,000	2,040,000	3,500,000	8,710,000
1993	1,310,000	1,630,000	2,940,000	7,920,000 r/	37	1,540,000	1,920,000	3,460,000	9,300,000 r/
1994	1,580,000	1,500,000	3,080,000	8,460,000	36	2,480,000	2,360,000	4,840,000	13,300,000
COPPER 8/									
1990	774,000	537,000	1,310,000	2,920,000	44.8	2,100,000	1,460,000	3,560,000	7,940,000
1991	682,000	518,000	1,200,000	2,730,000	44.0	1,650,000	1,250,000	2,890,000	6,580,000
1992	723,000	555,000	1,280,000	3,030,000	42.2	1,710,000	1,310,000	3,030,000	7,170,000
1993	748,000	543,000	1,290,000	3,260,000	39.6	1,510,000	1,100,000	2,610,000	6,590,000
1994	827,000	500,000	1,330,000	3,500,000	37.9	2,030,000	1,230,000	3,250,000	8,580,000
LEAD 9/									
1990	48,100	874,000	922,000	1,350,000	68.5	48,800	887,000	936,000	1,360,000
1991	55,000	830,000	885,000	1,280,000	68.9	40,600	612,000	653,000	947,000
1992	55,400	861,000	916,000	1,330,000	69.1	42,900	666,000	709,000	1,030,000
1993	55,000 r/	838,000 r/	893,000 r/	1,380,000 r/	64.7 r/	38,500	587,000	625,000	966,000
1994	55,100	858,000	913,000	1,460,000	62.3	45,200	703,000	748,000	1,200,000
NICKEL 10/									
1990	--	--	57,400	170,000	33.74	--	--	509,000	1,510,000
1991	--	--	53,500	157,000	34.16	--	--	436,000	1,280,000
1992	--	--	55,900	159,000	35.06	--	--	391,000	1,120,000
1993	--	--	54,000	159,000	34.34	--	--	386,000 r/	839,000 r/
1994	NA	NA	58,600	164,000	35.64	NA	NA	371,000	1,040,000
TIN 11/									
1990	4,040	13,200	17,300	53,400	32	34,300	112,000	147,000	455,000
1991	5,110	7,980	13,100	39,600	33	41,500	64,800	106,000	317,000
1992	4,890	8,850	13,700	37,300	37	43,400	78,400	122,000	331,000
1993 r/	4,630	7,420	12,000	43,300	28	35,700	57,300	92,900	334,000
1994	3,990	6,910	10,900	40,300	27	32,400	56,200	88,600	328,000
ZINC 12/									
1990	232,000	109,000	341,000	1,240,000	27.5	381,000	179,000	560,000	2,040,000
1991	233,000	119,000	353,000	1,170,000	30.3	271,000	138,000	410,000	1,360,000
1992	234,000	132,000	366,000	1,280,000	28.7	301,000	170,000	471,000	1,640,000
1993	246,000	109,000	355,000	1,370,000	26.0 r/	250,000	111,000	361,000	1,400,000
1994	251,000	116,000	367,000	1,420,000	25.9	213,000	126,000	389,000	1,540,000

r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ New scrap is scrap that results from the manufacturing process, including metal and alloy production.

3/ Old scrap is scrap that results from consumer products.

4/ Recycled metal is metal recovered from new plus old scrap.

5/ Apparent supply is production plus net imports plus stock changes. Production is primary production plus recycled metal. Net imports is imports minus exports. Apparent supply is calculated on a contained weight basis.

6/ Same as apparent supply defined above but calculated on a monetary value basis.

7/ Scrap quantity is the calculated metallic recovery from reported purchased new and old aluminum-based scrap, estimated for full industry coverage. Monetary value is estimated based on average U.S. market price for primary aluminum metal ingot.

8/ Monetary value of recovered copper for consumption is estimated as average annual refined copper prices.

9/ Lead processors are segregated by primary and secondary producers. This segregation permits inclusion of stocks changes for secondary producers. Monetary value of scrap and apparent supply estimated upon average quoted price of common lead.

10/ Nickel scrap is nickel contained in ferrous and nonferrous scrap receipts. Monetary value of scrap and apparent supply is estimated as average annual LME cash price of nickel cathode.

11/ Monetary value estimate based on Platt's Metals Week (PMW) Tin Composite price. Reevaluation of the tin canvass in 1991 resulted in a substantial lowering of estimated old scrap.

12/ Monetary value based on average annual U.S. zinc metal price published in PMW; for 1990, the PMW average prices were based on U.S. or North American Producers' High Grade zinc delivered prices and for 1991-94, the LME spot prices for Special High Grade zinc plus premiums based on market conditions.

TABLE 2
U.S. CONSUMPTION OF AND RECOVERY FROM PURCHASED NEW AND OLD ALUMINUM SCRAP 1/, BY CLASS 2/

(Metric tons)

Class	Consumption	Calculated recovery: Aluminum	Calculated recovery: Metallic
1993			
Secondary smelters	1,130,000	882,000	946,000
Integrated aluminum companies	1,340,000	1,120,000	1,190,000
Independent mill fabricators	608,000	524,000	559,000
Foundries	89,900	74,300	79,900
Other consumers	9,560	9,560	9,560
Total	3,190,000	2,610,000	2,790,000
Estimated full industry coverage	3,360,000	2,750,000	2,940,000
1994			
Secondary smelters	1,150,000	887,000	951,000
Integrated aluminum companies	1,340,000	1,120,000	1,190,000
Independent mill fabricators	728,000	628,000	670,000
Foundries	103,000	83,700	90,100
Other consumers	10,900	10,900	10,900
Total	3,340,000	2,730,000	2,910,000
Estimated full industry coverage	3,530,000	2,880,000	3,080,000

1/ Excludes recovery from other than aluminum-base scrap.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 3
U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF PURCHASED NEW AND OLD ALUMINUM SCRAP 1/ AND SWEATED PIG IN 1994 2/

(Metric tons)

Class of consumer and type of scrap	Stocks, Jan. 1	Net receipts 3/	Consumption	Stocks, Dec. 31
Secondary smelters:				
New scrap:				
Solids	4,250	167,000	167,000	4,720
Borings and turnings	3,970	188,000	187,000	4,490
Dross and skimmings	5,200	150,000	152,000	3,000
Other 4/	6,120	197,000	198,000	4,850
Total	19,500	702,000	705,000	17,100
Old scrap:				
Castings, sheet, clippings	15,000	294,000	292,000	16,800
Aluminum-copper radiators	1,100	9,060	9,340	816
Aluminum cans 5/	1,470 r/	101,000	100,000	1,680
Other 6/	254	41,400	41,200	453
Total	17,800 r/	445,000	443,000	19,700
Sweated pig	,298	2,790	2,580	,504
Total secondary smelters	37,600	1,150,000	1,150,000	37,300
Integrated aluminum companies, foundries, independent mill fabricators, other consumers:				
New scrap:				
Solids	12,800 r/	701,000	695,000	19,600
Borings and turnings	291	37,300	37,200	365
Dross and skimmings	14	13,600	13,500	89
Other 4/	11,300	232,000	234,000	9,320
Total	24,400 r/	984,000	979,000	29,400
Old scrap:				
Castings, sheet, clippings	7,490	380,000	378,000	9,080
Aluminum-copper radiators	163	2,610	2,400	371
Aluminum cans	10,700	815,000	803,000	22,600
Other 6/	737 r/	11,100	11,700	155
Total	19,100	1,210,000	1,200,000	32,300
Sweated pig	335	10,300	10,200	393
Total integrated aluminum companies, etc.	43,800 r/	2,200,000	2,190,000	62,000
All scrap consumed:				
New scrap:				
Solids	17,000 r/	869,000	861,000	24,300
Borings and turnings	4,260	225,000	224,000	4,850
Dross and skimmings	5,220	164,000	166,000	3,090
Other 4/	17,400	429,000	433,000	14,200
Total new scrap	43,900 r/	1,690,000	1,680,000	46,400
Old scrap:				
Castings, sheet, clippings	22,400	674,000	671,000	25,900
Aluminum-copper radiators	1,260	11,700	11,700	1,190
Aluminum cans	12,100	916,000	904,000	24,300
Other 6/	991 r/	52,500	52,900	608
Total old scrap	36,800	1,650,000	1,640,000	52,000
Sweated pig	633	13,100	12,800	897
Total of all scrap consumed	81,400 r/	3,350,000	3,340,000	99,300

r/ Revised.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes imported scrap. According to reporting companies, 9.69% of total receipts of aluminum-base scrap, or 323,000 metric tons, was received on toll arrangements.

3/ Includes inventory adjustment.

4/ Includes data on foil, can stock clippings, and other miscellaneous.

5/ Used beverage cans toll treated for primary producers are included in secondary smelter tabulation.

6/ Includes municipal wastes (includes litter) and fragmentized scrap (auto shredder).

TABLE 4
PRODUCTION AND SHIPMENTS OF SECONDARY ALUMINUM ALLOYS BY INDEPENDENT SMELTERS IN THE UNITED STATES 1/

(Metric tons)

	1993		1994	
	Production	Net shipments 2/	Production	Net shipments 2/
Die-cast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	45,500	44,700	50,500	51,200
380 and variations	518,000	517,000	559,000	560,000
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	85,100	84,400	86,400	85,900
No. 12 and variations	W	W	W	W
No. 319 and variations	67,400	65,700	70,500	71,200
F-132 alloy and variations	24,000	25,800	29,000	29,000
Al-Mg alloys	639	641	639	639
Al-Zn alloys	3,220	3,470	3,530	3,530
Al-Si alloys (0.6% to 2.0% Cu)	10,800	11,000	10,800	10,700
Al-Cu alloys (1.5% Si, maximum)	1,740	1,730	1,680	1,710
Al-Si-Cu-Ni alloys	1,360	1,400	1,180	1,230
Other	3,790	3,810	2,830	2,860
Wrought alloys: Extrusion billets	80,900	84,900	151,000	152,000
Miscellaneous:				
Steel deoxidation	--	--	--	--
Pure (97.0% Al)	--	--	--	--
Aluminum-base hardeners	93	93	93	93
Other 3/	34,200	35,200	35,700	35,000
Total	877,000	880,000	1,000,000	1,000,000
Less consumption of materials other than scrap:				
Primary aluminum	79,600	--	86,000	--
Primary silicon	39,200	--	67,500	--
Other	4,600	--	5,880	--
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot 4/	753,000	XX	843,000	XX

W Withheld to avoid disclosing company proprietary data; included with "Sand and permanent mold: Other." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes inventory adjustment.

3/ Includes other die-cast alloys and other miscellaneous.

4/ No allowance made for melt-loss of primary aluminum and alloying ingredients.

TABLE 5
U.S. EXPORTS OF ALUMINUM SCRAP, BY COUNTRY 1/

Country	Remelt scrap ingot		Used beverage container scrap		Other aluminum waste and scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
Belgium	--	--	--	--	26	$24	26	$24
Brazil	--	--	--	--	707	779	707	779
Canada	--	--	154	$134	46,300	47,200	46,500	47,300
China	17	$17	14	27	7,540	5,440	7,570	5,480
Finland	--	--	--	--	5,920	4,400	5,920	4,400
France	--	--	--	--	582	785	582	785
Germany	--	--	--	--	85	217	85	217
Hong Kong	455	331	--	--	7,510	5,280	7,970	5,620
Italy	--	--	3	3	52	53	55	56
Japan	27,000	32,500	134	111	65,200	62,200	92,300	94,800
Korea, Republic of	280	291	38	40	7,840	9,480	8,160	9,810
Mexico	4,820	6,580	--	--	13,500	13,400	18,300	20,000
Netherlands	78	118	--	--	195	187	272	305
Philippines	9	28	--	--	126	101	135	129
Taiwan	1,380	1,450	183	555	14,700	9,630	16,300	11,600
Thailand	--	--	--	--	1,030	1,130	1,030	1,130
United Kingdom	--	--	16	15	213	409	229	424
Other	1,490	1,660	455	606	3,550	6,240	5,490	8,510
Total	35,500	43,000	996	1,490	175,000	167,000	212,000	211,000
1994:								
Belgium	--	--	--	--	37	80	37	80
Brazil	--	--	2	6	628	862	631	868
Canada	--	--	64	70	57,900	61,100	57,900	61,200
China	415	554	7	6	13,400	10,000	13,800	10,600
Finland	--	--	--	--	4,750	2,630	4,750	2,630
France	--	--	--	--	33	211	33	211
Germany	--	--	--	--	189	144	189	144
Hong Kong	1,240	1,720	--	--	17,900	20,300	19,200	22,000
Italy	--	--	--	--	146	160	146	160
Japan	33,100	45,700	66	73	72,100	84,500	105,000	130,000
Korea, Republic of	257	342	--	--	15,800	20,400	16,100	20,700
Mexico	4,910	7,430	286	451	18,800	22,600	24,000	30,500
Netherlands	52	47	--	--	160	342	212	389
Philippines	--	--	--	--	37	21	37	21
Taiwan	3,070	3,550	108	128	52,900	47,000	56,100	50,700
Thailand	1,200	2,050	--	--	321	551	1,530	2,610
United Kingdom	--	--	--	--	52	45	52	45
Other	818	1,330	33	84	6,540	13,200	7,390	14,600
Total	45,100	62,700	565	818	262,000	284,000	307,000	348,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM SCRAP, BY COUNTRY 1/

Country	Remelt scrap ingot		Used beverage container scrap		Other aluminum waste and scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
Australia	--	--	53	$27	247	$169	300	$196
Bahamas, The	--	--	--	--	354	102	354	102
Brazil	--	--	--	--	4	14	4	14
Canada	225	$223	21,900	17,400	157,000	148,000	179,000	166,000
China	--	--	--	--	199	183	199	183
Colombia	--	--	711	571	329	320	1,040	891
Germany	8,060	8,670	--	--	1,130	1,100	9,190	9,770
Guatemala	--	--	56	46	847	298	902	344
Honduras	--	--	--	--	136	97	136	97
Jamaica	--	--	--	--	482	255	482	255
Japan	--	--	84	53	165	446	250	499
Mexico	159	43	19,200	15,800	27,200	22,100	46,500	38,000
Netherlands	3,650	4,880	20	18	1,260	1,210	4,930	6,120
Panama	14	10	1,330	1,130	769	662	2,120	1,800
Russia	1,180	1,180	--	--	17,500	17,000	18,600	18,200
South Africa, Republic of	--	--	--	--	21	4	21	4
Spain	359	368	--	--	31	40	390	408
Ukraine	110	698	--	--	--	--	110	698
United Kingdom	2,100	2,360	60	53	2,560	2,200	4,730	4,620
Venezuela	3,200	3,100	7,080	4,020	15,500	9,790	25,700	16,900
Other	618	682	1,380	1,040	11,800	9,320	13,800	11,000
Total	19,700	22,200	51,800	40,200	237,000	214,000	309,000	276,000
1994:								
Australia	--	--	91	124	908	759	999	883
Bahamas, The	--	--	--	--	417	124	417	124
Brazil	--	--	--	--	8	23	8	23
Canada	376	471	27,900	29,500	186,000	218,000	214,000	248,000
China	--	--	13	15	91	121	104	136
Colombia	120	185	94	100	742	731	956	1,020
Germany	11,000	13,700	237	252	1,240	1,200	12,500	15,200
Guatemala	--	--	35	5	1,330	961	1,370	966
Honduras	--	--	102	132	140	141	242	272
Jamaica	--	--	9	19	691	429	699	448
Japan	35	87	439	553	304	399	779	1,040
Mexico	362	151	35,600	42,600	32,600	33,300	68,500	76,100
Netherlands	3,440	4,270	--	--	1,360	1,450	4,800	5,720
Panama	--	--	1,710	1,740	1,630	1,600	3,340	3,340
Russia	611	492	--	--	13,100	18,600	13,700	19,100
South Africa, Republic of	--	--	--	--	495	170	495	170
Spain	512	583	42	28	61	46	616	658
Ukraine	--	--	--	--	190	147	190	147
United Kingdom	3,390	4,110	456	502	9,670	10,100	13,500	14,700
Venezuela	5,410	7,210	5,630	5,620	24,800	19,800	35,800	32,600
Other	1,280	1,430	3,740	4,020	11,500	9,750	16,600	15,200
Total	26,600	32,700	76,100	85,200	287,000	318,000	390,000	436,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
COPPER RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY 1/

(Metric tons)

	1993	1994
KIND OF SCRAP		
New scrap:		
Copper-base	719,000 r/	792,000
Aluminum-base	28,400	35,100
Nickel-base	117	89
Zinc-base	--	--
Total	748,000 r/	827,000
Old scrap:		
Copper-base	509,000 r/	472,000
Aluminum-base	33,300	28,100
Nickel-base	41	14
Zinc-base	17	23
Total	543,000 r/	500,000
Grand total	1,290,000	1,330,000
FORM OF RECOVERY		
As unalloyed copper:		
At electrolytic plants	337,000	269,000
At other plants	132,000	134,000
Total	470,000	403,000
In brass and bronze	759,000 r/	860,000
In alloy iron and steel	654	583
In aluminum alloys	61,100 r/	62,800
In other alloys	206	115
In chemical compounds	217	219
Total	821,000 r/	924,000
Grand total	1,290,000	1,330,000

r/ Revised.

1/ Previously published and 1994 data are rounded to three significant digits; may not add to totals shown.

TABLE 8
COPPER RECOVERED AS REFINED COPPER AND IN ALLOYS AND OTHER FORMS FROM COPPER-BASE SCRAP PROCESSED IN THE UNITED STATES, BY TYPE OF OPERATION 1/

(Metric tons)

	From new scrap		From old scrap		Total	
Type of operation	1993	1994	1993	1994	1993	1994
Ingot makers	34,700	34,000	92,100	93,500	127,000	128,000
Refineries 2/	113,000	92,900	347,000	299,000	460,000	392,000
Brass and wire-rod mills	552,000 r/	639,000	38,700 r/	46,900	590,000 r/	686,000
Foundries and manufacturers	19,900	25,300	31,600	32,900	51,600 r/	58,300
Chemical plants	217	219	--	--	217	219
Total	719,000 r/	792,000	509,000 r/	472,000	1,230,000 r/	1,260,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Electrolytically refined and fire-refined scrap based on source of material at smelter level.

TABLE 9
PRODUCTION OF SECONDARY COPPER AND COPPER-ALLOY PRODUCTS IN THE UNITED STATES, BY ITEM PRODUCED FROM SCRAP 1/

(Metric tons)

Item produced from scrap	1993	1994
Unalloyed copper products		
Electrolytically refined copper	337,000	269,000
Fire-refined copper	123,000	122,000
Copper powder	9,180	10,600
Copper castings	631	697
Total	470,000	403,000
Alloyed copper products		
Brass and bronze ingots:		
Tin bronzes	15,200	14,800
Leaded red brass and semi-red brass	91,400	95,400
High leaded tin bronze	10,100	11,300
Yellow brass	7,420	8,290
Manganese bronze	6,760	7,500
Aluminum bronze	7,930	8,070
Nickel silver	2,230	3,070
Silicon bronze and brass	7,080	7,630
Copper-base hardeners and master alloys	7,860	9,680
Miscellaneous	5,440	1,360
Total	161,000	167,000
Brass mill and wire rod mill products	733,000	849,000
Brass and bronze castings	43,900	49,000
Brass powder	263	342
Copper in chemical products	217	219
Grand total	1,410,000	1,470,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 10
COMPOSITION OF SECONDARY COPPER-ALLOY PRODUCTION IN THE UNITED STATES 1/

(Metric tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze ingot production: 2/							
1993	131,000	4,850 r/	8,230 r/	17,300	319	42	161,000
1994	135,000	4,850	8,300	18,200	244	35	167,000
Secondary metal content of brass mill products:							
1993	590,000	612	6,050	134,000	W	W	733,000
1994	686,000	882	6,730	152,000	W	W	849,000
Secondary metal content of brass and bronze castings:							
1993	38,900	837	1,420	2,460	78	138	43,900
1994	43,800	1,000	1,460	2,480	110	131	49,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ About 96% from scrap and 4% from other than scrap in 1993 and in 1994.

TABLE 11
CONSUMPTION AND YEAR ENDING STOCKS OF COPPER-BASE SCRAP 1/

(Metric tons, gross weight)

	1993		1994	
Scrap type and processor	Consumption	Stocks	Consumption	Stocks
No. 1 wire and heavy:				
Smelters, refiners and ingot makers	178,000	7,210	151,000	7,740
Brass and wire-rod mills	274,000	NA	329,000	NA
Foundries and misc. manufacturers	28,600	NA	33,900	NA
No. 2 mixed heavy and light:				
Smelters, refiners and ingot makers	338,000	12,100	311,000	13,800
Brass and wire-rod mills	42,100	NA	46,200	NA
Foundries and misc. manufacturers	5,590	NA	4,170	NA
Total unalloyed scrap:				
Smelters, refiners and ingot makers	516,000	19,300	462,000	21,600
Brass and wire-rod mills	316,000	14,500 r/	375,000	13,900
Foundries and misc. manufacturers	34,200	2,840	38,100	3,320
Red brass: 2/				
Smelters, refiners and ingot makers	44,200	2,480	40,700	2,800
Brass mills	5,610	NA	8,340	NA
Foundries and misc. manufacturers	11,600	NA	13,300	NA
Leaded yellow brass:				
Smelters, refiners and ingot makers	24,000	1,460	25,400	1,410
Brass mills	309,000	NA	354,000	NA
Foundries and misc. manufacturers	1,960	NA	1,850	NA
Yellow and low brass:				
All plants	74,600	1,250	73,600	1,540
Cartridge cases and brass:				
All plants	54,300	NA	61,100	NA
Auto radiators:				
Smelters, refiners and ingot makers	65,700	2,010	64,700	1,910
Foundries and misc. manufacturers	6,100	NA	6,270	NA
Bronzes:				
Smelters, refiners and ingot makers	13,100	632	12,500	866
Brass mills and misc. manufacturers	10,500	NA	10,700	NA
Nickel-copper alloys:				
All plants	14,800	327	21,900	360
Low grade and residues:				
Smelters, refiners and misc. manufacturers	161,000	9,450	81,200	8,250
Other alloy scrap: 3/				
Smelters, refiners and ingot makers	27,900	1,530	50,300	2,840
Brass mills and misc. manufacturers	5,810	NA	6,900	NA
Total alloyed scrap:				
Smelters, refiners and ingot makers	376,000	19,100	316,000	20,000
Brass mills	428,000	24,300 r/	488,000	34,700
Foundries and misc. manufacturers	26,500	2,820 r/	29,000	3,340
Total scrap:				
Smelters, refiners and ingot makers	892,000	38,500	779,000	41,500
Brass and wire-rod mills	744,000	38,800 r/	862,000	48,600
Foundries and misc. manufacturers	60,700	5,650 r/	67,100	6,660

NA Not available. r/Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes composition turnings, silicon bronze, railroad car boxes, cocks and faucets, gilding metal, and commercial bronze.

3/ Includes refinery brass, beryllium copper, and aluminum bronze.

TABLE 12
CONSUMPTION OF PURCHASED COPPER-BASE SCRAP 1/ 2/

(Metric tons, gross weight)

	From new scrap		From old scrap		Total	
Type of operation	1993	1994	1993	1994	1993	1994
Ingot makers	46,500	45,600	136,000	139,000	183,000	185,000
Smelters and Refineries	179,000	158,000	529,000	436,000	709,000	594,000
Brass and wire-rod mills	704,000	806,000	40,000	56,700	744,000	862,000
Foundries, etc.	24,600 r/	29,300	36,100 r/	37,800	60,700 r/	67,100
Total	955,000	1,040,000	742,000	670,000	1,700,000	1,710,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Consumption at brass and wire-rod mills assumed equal to receipts.

TABLE 13
FOUNDRIES AND MISCELLANEOUS MANUFACTURERS CONSUMPTION OF BRASS INGOT AND REFINED COPPER AND COPPER SCRAP IN THE UNITED STATES 1/

(Metric tons)

Ingot type	1993	1994
Tin bronzes	32,800	30,800
Leaded red brass and semi-red brass	63,600 r/	71,800
Yellow, leaded and low brass 2/	7,540 r/	8,130
Manganese bronze	4,130	4,330
Nickel silver 3/	886	1,050
Aluminum bronze	4,160	3,630
Hardeners and master alloys 4/	3,010	2,650
Total brass ingot	116,000	122,000
Refined copper consumed	37,800	41,500
Copper scrap consumed	60,500	66,800

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes silicon bronze and brass.

3/ Includes copper nickel and nickel bronze and brass.

4/ Includes special alloys.

TABLE 14
AVERAGE PRICES FOR COPPER SCRAP AND ALLOY-INGOT, BY TYPE

(Cents per pound)

Year	Brass mills	Refiners	Dealers' buying (New York)		Alloy-ingot (New York)	
	No. 1 scrap	No. 2 scrap	No. 2 scrap	Red brass turnings and borings	No. 115 brass (85-5-5-5)	Yellow brass (405)
1993	81.28	69.65 r/	63.84	45.22	120.25 r/	116.92 r/
1994	100.83	85.15	69.83	47.45	121.50	118.54

r/ Revised.

Source: American Metal Market.

TABLE 15
U.S. EXPORTS OF COPPER SCRAP, BY COUNTRY 1/

Country or Territory	Unalloyed copper scrap				Copper-alloy scrap			
	1993		1994		1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	3,130	$1,400	1,130	$1,330	800	$2,500	4,060	$9,550
Canada	42,800	39,300	73,700	98,700	11,400	20,300	23,200	37,500
China	13,200	12,400	19,100	21,900	41,100	26,700	58,200	43,100
Germany	294	322	157	167	974	1,960	5,820	6,000
Hong Kong	10,000	7,690	13,700	12,900	4,230	4,050	10,100	7,590
India	690	695	1,830	1,700	39,400	30,100	59,700	42,000
Italy	231	278	445	818	124	147	3,810	5,480
Japan	25,300	44,000	19,700	39,100	17,900	28,900	14,600	47,100
Korea, Republic of	10,400	16,300	8,680	16,400	26,000	29,100	18,400	21,700
Mexico	430	459	177	194	724	925	1,320	2,400
Singapore	1,180	844	451	580	862	974	477	615
Spain	--	--	--	--	4	10	6,100	975
Sweden	--	--	--	--	645	1,230	681	1,350
Taiwan	1,080	759	1,420	2,090	4,400	2,190	4,040	3,870
Thailand	160	336	40	50	963	1,560	1,730	2,080
United Kingdom	102	110	41	61	761	492	1,380	3,040
Other	778 r/	1,180 r/	1,160	1,440	2,030 r/	2,500 r/	3,890	5,690
Total	110,000	126,000	142,000	197,000	152,000	154,000	218,000	240,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 16
U.S. IMPORTS FOR CONSUMPTION OF COPPER SCRAP, BY COUNTRY 1/

Country or Territory	Unalloyed copper scrap		Copper-alloy scrap		
	Quantity (metric tons)	Value 2/ (thousands)	Gross weight (metric tons)	Copper content e/ 3/ (metric tons)	Value (thousands)
1993	45,800	$74,100	154,000	111,000	$233,000
1994:					
Canada	58,300	98,000	20,600	14,900	41,000
Chile	121	156	11,300	8,130	25,400
Colombia	1,650	2,470	174	125	192
Costa Rica	272	368	553	398	407
Dominican Republic	733	1,340	782	563	1,230
Ecuador	829	1,030	84	60	128
Finland	2,630	4,940	--	--	--
Jamaica	110	141	532	383	384
Mexico	24,100	32,800	17,900	12,900	29,700
Panama	606	727	683	492	1,210
Taiwan	1,650	1,420	109	78	63
United Kingdom	738	1,190	460	331	354
Venezuela	5,750	8,100	3,320	2,390	2,480
Other	4,640	7,570	1,860	1,340	2,120
Total	102,000	160,000	58,400	42,000	105,000

e/ Estimated.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ C.i.f. value at U.S. port.

3/ Under the Harmonized Tariff System that was implemented Jan. 1989, copper content is no longer available. Content is estimated to be 72% of gross weight.

Source: Bureau of the Census.

TABLE 17

STOCKS AND CONSUMPTION OF NEW AND OLD LEAD SCRAP IN THE UNITED STATES, BY TYPE OF SCRAP 1/

(Metric tons, gross weight)

Type of scrap	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
1993						
Smelters, refiners, others:						
Soft lead 2/	357	13,700 r/	--	13,200 r/	13,200 r/	894 r/
Hard lead	W	W	--	5,480 r/	5,480 r/	W
Cable lead	699 r/	4,300 r/	--	W	W	W
Battery-lead	19,700 r/	846,000 r/	--	834,000 r/	834,000 r/	31,300 r/
Mixed common babbitt	62 r/	838 r/	--	839 r/	839 r/	61
Solder and tinny lead	W	W	--	W	W	W
Type metals	165 r/	W	--	2,960 r/	2,960 r/	W
Drosses and residues	974 r/	65,800 r/	65,300 r/	--	65,300 r/	1,420 r/
Other	5	103	--	93	93	15
Total	23,800 r/	946,000 r/	65,300 r/	868,000 r/	934,000 r/	36,100 r/
1994						
Smelters, refiners, others:						
Soft lead 2/	894	16,000	--	16,300	16,300	551
Hard lead	W	9,750	--	9,590	9,590	W
Cable lead	W	2,260	--	2,390	2,390	W
Battery-lead	31,300	1,010,000	--	1,010,000	1,010,000	30,200
Mixed common babbitt	61	W	--	W	W	W
Solder and tinny lead	W	W	--	W	W	W
Type metals	W	1,230	--	1,270	1,270	94
Drosses and residues	1,420	62,300	62,200	--	62,200	1,550
Other	15	W	--	W	W	W
Total	36,100	1,110,000	62,200	1,050,000	1,110,000	34,700

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes remelt lead from cable sheathing plus other soft lead scrap processing.

TABLE 18
SECONDARY METAL RECOVERED 1/ FROM LEAD AND TIN SCRAP IN THE UNITED STATES 2/

(Metric tons)

	Lead	Tin	Antimony	Other	Total
1993					
Refined pig lead 3/	444,000 r/	--	--	--	444,000 r/
Refined pig tin 4/	--	W	--	--	W
Lead and tin alloys:					
Antimonial lead	417,000 r/	748 r/	7,360 r/	W	425,000 r/
Lead-base babbitt	330	50	38	--	418
Solder	(5/)	(5/)	(5/)	W	(5/)
Type metal	849	43	118	3	1,010
Other alloys, including cable lead	15,900	3,850	74	--	19,800
Total	434,000 r/	4,690 r/	7,590 r/	3	446,000 r/
Grand total	878,000 r/	4,690 r/	7,590 r/	3	890,000 r/
1994					
Refined pig lead 3/	510,000	--	W	W	510,000
Refined pig tin 4/	--	W	--	--	W
Lead and tin alloys:					
Antimonial lead	371,000	733	8,480	W	380,000
Lead-base babbitt	W	39	W	W	39
Solder	(5/)	(5/)	(5/)	(5/)	(5/)
Type metal	827	41	114	W	982
Other alloys, including cable lead	15,000	3,340	39	327	18,700
Total	387,000	4,160	8,630	327	400,000
Grand total	897,000	4,160	8,630	327	910,000

r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Most of the figures herein represent actual reported recovery of metal from scrap.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes remelt lead.

4/ Includes remelt tin.

5/ Included with "Other alloys, including cable lead" to avoid disclosing company proprietary data.

TABLE 19
LEAD RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY 1/

(Metric tons)

	1993	1994
KIND OF SCRAP		
New scrap:		
Lead-base	48,200 r/	47,100
Copper-base	6,870 r/	8,000 e/
Tin-base	(2/)	--
Total	55,000 r/	55,100
Old scrap:		
Battery-lead	796,000 r/	816,000
All other lead-base	33,500 r/	33,800
Copper-base	8,780 r/	8,000 e/
Tin-base	--	--
Total	838,000 r/	858,000
Grand total	893,000 r/	913,000
FORM OF RECOVERY		
As soft lead	444,000 r/	510,000
In antimonial lead	417,000 r/	371,000
In other lead alloys	17,000	16,100
In copper-base alloys	15,600 r/	16,000 e/
In tin-base alloys	(2/)	1
Total	893,000 r/	913,000
Value 3/ thousands	$625,000 r/	$748,000

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Revised to zero.

3/ Value based on average quoted price of common lead.

TABLE 20
U.S. EXPORTS AND IMPORTS FOR CONSUMPTION OF LEAD SCRAP, BY COUNTRY 1/

Country	1993 Quantity (metric tons)	1993 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
EXPORTS				
Scrap (gross weight):				
Antigua and Barbuda	1	$20	91	$16
Bahamas, The	119	54	(2/)	27
Belgium	30	3	22	64
Brazil	4,680	643	4,110	936
Canada	38,700	6,840	68,400	13,000
Cayman Islands	--	--	100	10
China	1,550	372	458	288
Colombia	452	84	15	320
Costa Rica	30	24	558	208
Germany	105	35	15	119
Hong Kong	656	323	49	19
India	970	237	941	156
Jamaica	--	--	34	3
Japan	520	511	127	321
Korea, Republic of	2,680	3,000	9,440	6,070
Malaysia	134	59	--	--
Mexico	2,030	1,010	903	1,140
Panama	--	--	137	37
Philippines	107	42	--	--
Russia	--	--	34	78
Singapore	1	66	782	292
Spain	26	15	--	--
Taiwan	522	149	250	113
Thailand	189	23	(2/)	3
United Arab Emirates	39	4	268	27
United Kingdom	457	219	903	292
Venezuela	4	80	315	83
Other	113 r/	622 r/	143	864
Total	54,100	14,400	88,100	24,500
IMPORTS				
Reclaimed scrap, including ash and residues (lead content): 3/				
Canada	58	29	128	39
Other	19 r/	11	16	40
Total	78 r/	39	144	80

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Also includes other lead-bearing materials containing greater than 10% by weight of copper, lead, or zinc (any one).

Source: Bureau of the Census.

TABLE 21
TIN RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY FORM OF RECOVERY 1/

(Metric tons unless otherwise specified)

Form of recovery	1993	1994
Tin metal 2/	W	W
Bronze and brass e/ 3/	10,300 r/	10,800
Lead and tin alloys:		
Antimonial lead	748 r/	733
Babbitt	51	W
Type metal	43	41
Other alloys 4/	(5/)	(5/)
Total	842 r/	774
Tin content of chemical products	W	W
Grand total	11,100 r/	11,600
Value (thousands) e/ 6/	$85,900 r/	$94,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Grand total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes tin metal recovered at detinning and other plants.

3/ Includes tin recovered from copper-, lead-, and tin-base scrap.

4/ Includes foil, solder, terne metal, and cable lead.

5/ Withheld to avoid disclosing company proprietary data; not included in "Total."

6/ Based on Platt's Metals Week composite price.

TABLE 22
U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF NEW AND OLD SCRAP AND TIN RECOVERED, BY TYPE OF SCRAP 1/

(Metric tons)

Type of scrap	Gross weight of scrap						Tin recovered e/ 2/		
	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31			
			New	Old	Total		New	Old	Total
1993									
Copper-base scrap	5,680	132,000	29,500	102,000	131,000	6,190	1,460	3,430	4,890
Brass mills 3/	--	26,300	26,300	(4/)	26,300	--	613	--	613
Foundries and other plants	2,560	20,900	9,620	11,500	21,100	2,290 r/	401	470	871
Total tin from copper-base scrap	XX	XX	XX	XX	XX	XX	2,480	3,900	6,370
Lead-base scrap r/	23,100	921,000	65,300	845,000	910,000	34,100	1,720	3,010	4,720
Tin-base scrap 5/	W	46	W	44	W	W	W	43	43
Grand total	XX	XX	XX	XX	XX	XX	4,190 r/	6,950 r/	11,100 r/
1994									
Copper-base scrap	6,190	129,000	26,600	102,000	129,000	6,570	1,270	3,520	4,800
Brass mills 3/	--	55,600	47,400	W	47,400	--	802	W	802
Foundries and other plants	2,290	24,200	10,200	13,500	23,800	2,730	477	574	1,050
Total tin from copper-base scrap	XX	XX	XX	XX	XX	XX	2,550	4,100	6,650
Lead-base scrap	34,100	1,080,000	62,200	1,020,000	1,080,000	33,000	1,630	3,230	4,860
Tin-base scrap 5/	W	59	W	53	W	W	W	51	51
Grand total	XX	XX	XX	XX	XX	XX	4,180	7,380	11,600

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Tin recovered from new and old copper-base scrap, brass mills, and foundries.

3/ Brass-mill stocks include home scrap, and purchased-scrap consumption is assumed equal to receipts; therefore, line does not balance.

4/ Revised to zero.

5/ Includes tinplate and other scrap recovered at detinning plants; U.S. Bureau of Mines not at liberty to publish separately.

TABLE 23
STOCKS AND CONSUMPTION OF NEW AND OLD ZINC SCRAP IN THE UNITED STATES IN 1994, BY TYPE OF SCRAP

(Metric tons, zinc content)

Type of scrap	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
Diecastings	W	4,620	--	4,550	4,550	W
Flue dust	W	10,500	4,940	4,920	9,860	4,380
Fragmentized diecastings	W	W	--	W	W	W
Galvanizer's dross	2,470	65,300	65,800	--	65,800	1,970
Old zinc 1/	85	839	--	863	863	61
Remelt die-cast slab	W	W	--	W	W	W
Remelt zinc 2/	W	W	W	--	W	W
Skimmings and ashes 3/	7,040	29,500	29,900	--	29,900	6,640
Steelmaking dust	W	W	W	W	W	W
Other 4/	4,980	88,300	6,110	81,600	87,700	1,850
Total	14,600	199,000	107,000	91,900	199,000	14,900

W Withheld to avoid disclosing company proprietary data; included in "Other."

1/ Includes engraver's plates and rod and die scrap.

2/ Includes new clippings.

3/ Includes sal skimmings and die-cast skimmings.

4/ Includes chemical residues and solutions and electrogalvanizing anodes.

TABLE 24
PRODUCTION OF ZINC PRODUCTS FROM ZINC-BASE SCRAP IN THE UNITED STATES 1/

(Metric tons)

Products	1993	1994
Electrogalvanizing anodes	W	W
Redistilled slab zinc	141,000	139,000
Remelt die-cast slab	W	W
Other metal alloys	W	W
Other zinc metal products	13,700	5,960
Secondary zinc in chemical products	65,000	70,700
Zinc dust	16,500	22,300

W Withheld to avoid disclosing company proprietary data; included in "Other zinc metal products."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

TABLE 25
ZINC RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY 1/

(Metric tons)

	1993	1994
KIND OF SCRAP		
New scrap:		
Zinc-base	108,000	102,000
Copper-base	137,000	149,000
Magnesium-base	33	28
Total	245,000	251,000
Old scrap:		
Zinc-base	91,000	90,000
Copper-base	17,300	25,200
Aluminum-base	873	707
Magnesium-base	44	43
Total	109,000	116,000
Grand total	354,000	367,000
FORM OF RECOVERY		
Metal:		
Slab zinc	141,000	139,000
Zinc dust	16,500	22,300
Other1/	10,900	3,050
Total	158,000	161,000
In zinc-base alloys	W	W
In brass and bronze	116,000	119,000
In other metal alloys	W	W
In chemical products:		
Zinc oxide (lead free)	36,000	36,800
Zinc sulfate	18,700	W
Zinc chloride	4,240	9,170
Miscellaneous	11,300	37,200
Total	333,000	363,000
Grand total	491,000	524,000

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes electrogalvanizing anodes and zinc content of slab made from remelt die-cast slab.

RHENIUM

By John W. Blossom

Rhenium's two most important uses in the past decade have been in platinum-rhenium catalysts used primarily in producing lead-free, high-octane gasoline and in high-temperature superalloys for jet engine components. Other uses of rhenium, primarily as tungsten-rhenium and molybdenum-rhenium alloys, though smaller in quantity, are more diverse. These include use in thermocouples, heating elements, temperature controls, flashbulbs, vacuum tubes, X-ray tubes and targets, metallic coatings, and electrical contact points. Research by industry continues in rhenium recovery from ore and concentrate and on development of new catalysts and alloys.

In 1994, domestic demand for rhenium metal and other rhenium products was met by domestic recovery, domestic stocks, and imports.

Domestic mine production data for rhenium are developed by the U.S. Bureau of Mines from reported molybdenum production at the eight operating porphyry copper-molybdenum-rhenium mines in the United States.

Rhenium is a byproduct of molybdenite recovered as a byproduct of porphyry copper ore from eight mines in the Western United States. Consumption of rhenium increased about 87% in 1994. Imports for consumption increased 40% in 1994. The major uses for rhenium during the year were bimetallic platinum-rhenium catalysts and jet engine high-temperature components. The average prices for metal powder had a range of $1,433 to $1,680 per kilogram and ammonium perrhenate had a range of $1,047 to $1,102 per kilogram.

Consumption

The major uses of rhenium are in petroleum-reforming catalysts and in high-temperature superalloys used in jet engine components.

Rhenium is used in petroleum-reforming catalysts for the production of high-octane hydrocarbons, which are used in the production of lead-free gasoline. Bimetallic platinum-rhenium catalysts have replaced many of the monometallic catalysts. Rhenium catalysts tolerate greater amounts of carbon formation and make it possible to operate at lower pressures and higher temperatures, which leads to improved yields and octane ratings.

Catalytic units employing platinum-rhenium catalysts are used in about 80% of total U.S. reforming capacity. Platinum-rhenium catalysts also are used in the production of benzene, toluene, and xylenes, although this use is small compared with that used in gasoline production.

A significant property of rhenium is its ability to alloy with molybdenum and tungsten. Molybdenum alloys containing approximately 50-weight-percent rhenium have greater ductility and can be fabricated by either warm or cold working. Unlike other molybdenum alloys, this alloy is ductile, even at temperatures down to 196° C, and can be welded. Also, alloys of tungsten with 24-weight-percent rhenium have improved ductility and lower ductile-to-brittle transition temperature than pure tungsten. Rhenium improves the strength properties at high temperatures (1,000° C) of nickel alloys. Some of the uses for these alloys are in thermocouples, temperature controls, heating elements, ionization gauges, mass spectrographs, electron tubes and targets, electrical contacts, metallic coatings, vacuum tubes, crucibles, electromagnets, and semiconductors. These various uses represented only 10% of total demand in 1994.

Foreign Trade

Imports for consumption of ammonium perrhenate came from Chile, Germany, Japan, the Netherlands, and Sweden, whereas Chile, Germany, and Japan supplied rhenium metal.

World production of rhenium was estimated to be 39 metric tons (87,000 pounds); however, the quantity of rhenium actually recovered is much lower because not all concentrates are processed to recover the rhenium values. Rhenium was recovered from some byproduct molybdenite concentrates from porphyry copper deposits in Canada, Chile, China, Iran, Kazakhstan, Peru, Russia, and the United States. Rhenium metal and compounds were recovered from molybdenum concentrates in Chile, France, Germany, Russia, Sweden, the United Kingdom, and the United States.

World Review

The definitions of reserves and reserve base are published in Appendix C of U.S. Bureau of Mines "Mineral Commodity Summaries, 1995."

They are contained primarily in molybdenite in porphyry copper deposits. U.S. reserves are concentrated in Arizona and Utah, but also are found in Montana, Nevada, and New Mexico. Canadian reserves are in British Columbia, primarily on Vancouver Island. Chilean reserves are found primarily at four large porphyry copper mines and in lesser deposits in the northern one-half of the country. In Peru, reserves are concentrated primarily in the Toquepala open pit porphyry copper mine and in about a dozen other deposits in the southern one-half of the country.

Reserves in the former U.S.S.R. are in several porphyry copper deposits and one sedimentary copper deposit mainly in the south-central part of the country between the Caspian Sea and northwestern China. Other world reserves are in Europe and in sedimentary copper-cobalt deposits in Zaire.

Outlook

In the next 5 years, demand for rhenium metal will increase from the 1994 level. The demand will follow the demand for aircraft engines and for petroleum. For the long term (10-20 years), recycling of rhenium-bearing waste and scrap must be greatly improved. As identified, U.S. resources are estimated to be about 5,000 metric tons, and identified rest-of-world resources are on the order of 6,000 metric tons.

TABLE 1
SALIENT U.S. RHENIUM STATISTICS 1/

(Kilograms)

	1990	1991	1992	1993	1994
Mine production 2/	17,500	19,200	16,000	12,200	15,500
Consumption e/	7,710	8,870	6,800	6,900	12,900
Imports (metal)	5,890	10,800	6,390	2,700	5,870
Imports (ammonium perrhenate)	3,000	3,510	5,690	3,170	2,330

e/ Estimated.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Calculated rhenium contained in molybdenite concentrates.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF RHENIUM METAL, BY COUNTRY 1/

Country	1993		1994	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Chile	1,930	$2,460	4,090	$4,360
Germany	612	713	1,480	1,220
Japan	146	152	301	305
Other 2/	8 r/	10 r/	6	6
Total	2,700	3,330	5,870	5,890

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes France, Hungary, Switzerland and the United Kingdom.

Source: Bureau of the Census.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM PERRHENATE, BY COUNTRY 1/

Country	1993		1994	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Chile	--	--	717	$308
Denmark	98	$48	--	--
Germany	82	41	458	185
Japan	--	--	1	1
Netherlands	1,710	872	993	463
Sweden	1,270	639	159	54
Total	3,170	1,600	2,330	1,010

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census; minor adjustment by the U.S. Bureau of Mines.

SALT

By Dennis S. Kostick

Sodium chloride, commonly known as salt, is a universal commodity that is known and used by virtually every person in the world. It is an important compound that has a multitude of applications with approximately 14,000 different reported uses, the largest of which is as a mineral feedstock used by the chemical industry. Most individuals usually associate salt with highway deicing and food processing; however, its largest use is as feedstock for chlorine and caustic soda manufacture. These two important inorganic chemicals have a multitude of consumer-related end-use products, such as polyvinyl chloride (PVC) plastic made from chlorine and pulping chemicals manufactured from caustic soda.

Production

Domestic production data for salt are developed by the U.S. Bureau of Mines (USBM) from an annual voluntary survey of U.S. salt-producing sites and of company operations. Of the 27 companies to which a survey request was sent, all but one responded, representing 98% of the total production shown in this report. Data for the one company was estimated on the basis of its prior responses to previous annual surveys, the 1994 production estimate survey, or brine production capabilities for chloralkali manufacture based upon chlorine production capacities.

Total U.S. salt production increased only about 2% in 1994 compared with the previous year; however, rock salt production rose 6% because of strong demand for deicing salt that was forecast based on the previous winter's adverse weather. According to the USBM survey for 1994, 27 companies operated 67 salt-producing plants in 14 States. Nine of the companies and 12 of the plants produced more than 1 million metric tons each and accounted for 91% and 59%, respectively, of the U.S. total. Several companies and plants produced more than one type of salt. In 1994, 11 companies (15 operations) produced solar-evaporated salt; 5 companies (17 operations), vacuum pan salt; 10 companies (14 operations), rock salt; and 14 companies (29 operations), salt brine. *(See tables 1, 2, and 3.)*

The five leading States in terms of total salt sold or used were Louisiana, 34%; Texas, 20%; New York, 15%; and Kansas, 7%. Although Louisiana, New York, and Ohio were major rock salt-producing States, a substantial amount of salt was produced in Alabama, Kansas, Louisiana, New York, Ohio, Texas, Utah, and West Virginia as brine for the chemical industry. *(See table 4.)*

U.S. salt production accounted for about 22% of total world production. Production and trade of salt increased compared with the previous year. Total world production of all types of salt decreased slightly. The depressed market for chlorine and environmental problems associated with emissions of chlorinated compounds may affect the short-term status of the world chloralkali industry, which is the largest single consumer of salt.

In February 1994, Akzo N.V. of the Netherlands merged with Nobel Industrier A.B. of Sweden to form Akzo Nobel N.V. The joint venture resulted in changing the name of its U.S. salt subsidiary to Akzo Nobel Salt Inc.[1]

At 5:43 a.m. on Saturday, March 12, 1994, the nation's largest and one of its oldest underground rock salt mines experienced a major roof collapse that gave a seismic signature as if it were a 3.6 magnitude earthquake.[2] The accident happened at Akzo Salt's Retsof mine near Rochester, NY, which had an annual rock salt production capacity of 3.63 millions tons (4.0 million short tons) and has been in continuous mining since 1885 when it began as the Retsof Mining Co. The mine celebrated its 100 millionth ton of salt produced in 1984 which coincided with the mine's centennial of when it sunk its first shaft. The mine reportedly was the largest salt mine in the world and the largest room-and-pillar mine in the Western Hemisphere.

A 183 meter-by-183 meter (600 foot-by-600 foot) section of the roof in the southeast section of the mine unexpectedly fell and created a 43 meter (140 foot) long fracture in the overlying limestone causing water from an overhead aquifer to enter and flood the mine at the rate of 20,800 liters (5,500 gallons) per minute (equal to 30.3 million liters or 8 million gallons daily).[3] By May, the rate had increased to nearly 68,100 liters (18,000 gallons) per minute (equal to 98.4 million liters or 26 million gallons daily). The decision was made to continue to mine in the safe areas of the mine until about September 1995 when the mine would have to be permanently abandoned and closed.

Efforts were made to drill down to the fracture and use chemical grout to seal the fissures and stop the flooding; however, the efforts were unsuccessful. After obtaining a permit from the New York State Department of Environmental Conservation, Akzo began pumping the salt brine to the Genesee River to reduce the volume of water and to allow the grout to work but the inflow of fresh water only dissolved more of the pillars causing major surface subsidence.

On November 2, 1994, Akzo announced plans to construct a new rock salt mine at Hampton Corners in the town of Groveland to replace the Retsof mine, which contributed about $50 million annually to the local economy.[4] The proposed mine would cost $120 million when completed. The company was optimistic about retaining its workforce and guaranteed its customers that the mine disaster would not affect the availabilty of salt in the near future. Akzo increased production output at its other mines in Louisiana and Ohio and imported additional supplies of salt from the Caribbean and Chile to offset any shortages. Other U.S. salt companies also increased production and imports to anticipate any shortages resulting from Akzo's accident.

Consumption

A record 47.2 million metric tons of domestic and imported salt was consumed in the United States in 1994, based on the annual survey of the U.S. salt producers.

The reported percent distribution of salt by major end use was chemicals, 39%; ice control, 35%; distributors, 10%; food and agricultural, 6%; industrial, 6%; primary water treatment, 1%; and other combined with exports, 3%. Distributors represent a substantial share of salt sales by the salt industry; however, all the salt ultimately is resold to many end users. Some customers have specific uses. For a more complete analysis of end-use markets, specific sectors of distribution in table 5 can be combined, such as agricultural and water conditioning with agricultural and water conditioning distribution, respectively.

The chemical industry consumes the majority of the salt produced, primarily salt brine. Although most salt brine is captively produced by chemical producers, many chloralkali manufacturers now purchase brine from independent brine supply companies. In certain cases, brine is captively produced by one chemical company, and any excess brine is sold to neighboring competitors. According to a survey of domestic salt-based chlorine facilities, about 48% of the salt used to manufacture chlorine was captive, and 31% was purchased brine. Purchased solar or rock salt comprised 12%, and imported rock, solar, and vacuum pan salt was 9%. *(See tables 5 and 6.)*

HoltraChem Manufacturing, a joint venture between Allied Signal and HoltraChem Group, completed its acquisition of the Hanlin Group's LCP chloralkali plants at Acme, NC, and Orrington, ME, and a terminal at Syracuse, NY. The two chlorine plants have an annual capacity of about 118,000 tons of chlorine and caustic soda.[5] On April 21, Elf Atochem North America Inc., closed its chloralkali plant in Tacoma, WA, because local pulp mills have begun converting to oxygen-base bleaching agents and discontinuing use of chlorine-base chemicals, such as those made at the Tacoma facility. The plant had a chlorine capacity of about 70,000 tons.[6]

Using Bureau of the Census data, the chlorine and caustic soda industry consumed about 19.2 million tons (21.2 million short tons) of salt for feedstock, based on the industry average ratio of 1.75 tons of salt required to produce 1.0 ton of chlorine and 1.1 tons of coproduct sodium hydroxide. Reported consumption of total domestic and imported salt for chlorine manufacture was 17.3 million tons (19.1 million short tons), as noted in table 5. The difference between the calculated and reported quantities was the amount of salt unreported to the USBM from imports or captive brine production of chloralkali producers. Production of chlorine gas and liquid sodium hydroxide, as reported by the Bureau of the Census, was 11.0 million tons 11.7 million tons, respectively.[7]

Salt for human consumption is packaged in different sized containers for several specialized purposes. Table salt may contain 0.01% potassium iodide as an additive that provides a source of iodine that is essential to the oxidation processes in the body. Kosher salt, seasalt, condiment salt, and salt tablets are special varieties of salt.

Water conditioning and animal feedstock salt are made into 22.7 kilogram (50-pound) pressed blocks. Sulfur, iodine, trace elements, and vitamins are occasionally added to salt blocks to provide missing nutrients not found naturally in the diet of certain livestock. Salt also is compressed into pellets and used for water conditioning.

There are reportedly about 14,000 different direct and indirect uses of salt. The USBM annually surveys 8 major categories comprising 29 separate end uses.

Chemical.—The greatest quantity of salt used in the chemical industry is by the chloralkali sector. Traditionally, the chloralkali sector included salt consumed for chlorine, coproduct sodium hydroxide (also known as caustic soda and lye), and synthetic soda ash. Since 1986 when the last synthetic soda ash plant closed because of high production costs and competition with less expensive natural soda ash, no synthetic soda ash has been manufactured in the United States. Aside from a few economic deposits of natural soda ash, several countries in the world continue to use salt for synthetic soda ash production.

Salt is used as the primary raw material in chlorine manufacture because it is an inexpensive and widely available source of chlorine ions. For sodium hydroxide production, salt is the main source of the sodium ions. About 98% of the domestic chlorine and sodium hydroxide produced is obtained from the electrolysis of salt brine feedstock using three different cell technologies. The types of cells and percent chlorine manufactured by them are diaphragm, 78%; mercury, 14%; and membrane, 6%.

It takes about 1.75 short tons of salt to make 1.0 short ton of chlorine and 1.1 short tons of coproduct caustic soda. The electrolytic process ionizes the sodium chloride compound and selectively allows the ions to migrate through special membranes. Chlorine gas forms at the anode while sodium ions bond with water molecules at the cathode to form sodium hydroxide with hydrogen gas evolving.

Chlorine and caustic soda are considered to be the first generation of products made from salt. These two chemicals are further used to manufacture other materials, which are considered second generation products from salt. Salt also is used as a feedstock chemical establishments that make sodium chlorate (by the electrolysis of an acidified salt brine using hydrochloric acid adjusted to a pH of 6.5), metallic sodium (by the electrolysis of a molten salt mixture containing 33.2% sodium chloride and 66.8% calcium chloride, which is added to reduce the melting temperature of salt), and other downstream chemical operations. In powdered soaps and detergents, salt is used as a bulking agent and as a coagulant for colloidal dispersion after saponification. In pharmaceuticals, salt is a chemical reagent and is used as the electrolyte in saline solutions. It also is used as a cofeedstock with sulfuric acid to produce sodium sulfate and hydrochloric acid. This subsector is relatively small, representing only 10% of domestic salt sales for the entire chemical sector and only 5% of total domestic salt consumption.

Food Processing.—Every person uses some quantity of salt in their food. The salt is either added to the food by the food processor or by the consumer through free choice. Salt is added to food as a flavor enhancer, preservative, binder, fermentation control additive, texture aid, and color developer. This major category is subdivided into six applications, in descending order of salt consumption; meat packers, canning, other food processing, baking, dairy, and grain mill products.

In meatpacking, salt is added to processed meats to promote the color development in bacon, ham, and other processed meat products. As a preservative, salt inhibits the growth of bacteria, which would lead to spoilage of the product. Early pioneers used to store their perishables in salt barrels for protection and preservation. Salt acts as a binder in sausages to form a binding gel comprised of meat, fat, and moisture. Salt also acts as a flavor enhancer and a tenderizer. In canning, salt is primarily added as a flavor enhancer and preservative. It also is used as a dehydrating agent, tenderizer, enzyme inhibitor, and as a carrier for other ingredients.

In the "other food processing" category, salt is used mainly as a seasoning agent. Other food processing includes miscellaneous establishments that make food for human consumption (i.e., potato chips, pretzels) and domestic pet consumption (i.e., dog and cat food). In baking, salt is added to control the rate of fermentation in bread dough. It also is used to strengthen the gluten (the elastic protein-water complex in certain doughs) and as a flavor enhancer, such as a topping on baked goods. In the dairy industry, salt is added to cheese as a fermentation control agent, and as a color and texture control agent. The dairy subsector includes companies that manufacture creamery butter, natural and processed cheese, condensed and evaporated milk, ice cream, frozen desserts, and specialty dairy products. The final food processing category is grain mill products, which consists of milling flour and rice, and manufacturing cereal breakfast food and blended or prepared flour.

General Industrial.—The industrial uses of salt are diverse. They include, in descending order of salt usage, oil and gas exploration; metal processing; other industrial; pulp and paper; textiles and dyeing; tanning and leather treatment; and rubber manufacture.

In oil and gas exploration, salt is an important component of drilling fluids in well drilling. It is used to flocculate and to increase the density of the drilling fluid in order to overcome high down-well gas pressures. Whenever drilling activities encounter salt formations, salt is added to the drilling fluid to saturate the solution and minimize the dissolution within the salt strata. Salt also is used to increase the set rate of concrete in cemented casings. In metal processing, salt is used in concentrating uranium ore into uranium oxide (yellow cake). It also is used in processing aluminum, beryllium, copper, steel, and vanadium.

In the pulp and paper industry, salt is used to bleach wood pulp. It also is used to make sodium chlorate, which is added along with sulfuric acid and water to manufacture chlorine dioxide—an excellent oxygen-base bleaching chemical. Although the chlorine dioxide process originated in Germany after World War I, it is becoming more popular because of environmental pressures to reduce or eliminate chlorinated bleaching compounds. In textiles and dyeing, salt is used as a brine rinse to separate organic contaminants, to promote "salting out" of dyestuff precipitates, and to blend with concentrated dyes to standardize them. One of its main roles is to provide the positive ion charge to promote the absorption of negatively charged ions of dyes. In tanning and leather treatment, salt is added to animal hides to inhibit microbial activity on the underside of the hides and to replace some of the moisture in the hides. In rubber manufacture, salt is used to make neoprene rubber, white rubber, and buna rubber. Salt brine and sulfuric acid are used to coagulate an emulsified latex made from chlorinated butadiene.

Agricultural Industry.—Since prehistoric times, humankind has noticed that animals satisfied their salt hunger by locating salt springs, salt licks, or playa lake salt crusts. Barnyard and grazing livestock need supplementary salt rations to maintain proper nutrition. Veterinarians advocate adding loose salt in commercially mixed feeds or in block forms sold to farmers and ranchers. Salt also acts as an excellent carrier for trace elements not found in the vegetation consumed by grazing livestock. Sulfur, selenium, and other essential elements are commonly added to salt licks, or salt blocks, for free-choice feeding.

Water Treatment.—Approximately 1.2 trillion liters (325 billion gallons) of water are used daily in the United States for residential and commercial uses. Many areas of the United States have "hard" water, which contains excessive calcium and magnesium ions that contribute to the buildup of a scale or film of alkaline mineral deposits in household and industrial equipment. Commercial and residential water-softening units use salt to remove the ions causing water hardness. The sodium ions captured on a resin bed are exchanged for the calcium and magnesium ions. Periodically, the water-softening units must be recharged because the sodium ions become depleted. Salt is added and dissolved, and the brine replenishes the lost sodium ions.

Ice Control and Road Stabilization.—The second largest end use of salt is for highway deicing. Gabriel Daniel Fahrenheit, the developer of the Fahrenheit temperature scale (° F), discovered that salt mixed with ice (at a temperature below the freezing point) creates a solution with a lower freezing point than water by itself. The brine forms below the surface of the ice and snow and prevents the water from freezing into ice and bonding with the road surface. Therefore, salt causes snow and ice to melt. Salt is an inexpensive, widely available, and effective ice control agent. It does, however, become less effective as the temperature decreases below about -9.4° C to -6.7° C (15° F to 20° F). At lower temperatures, more salt would have to be applied to maintain higher brine concentrations to provide the same degree of melting. Most winter snowstorms and ice storms occur between -3.9° C to 0° C (25° F and 32° F), a range in which salt is most effective.

In highway deicing, salt has been associated with corrosion to motor vehicles, bridge decks, unprotected steel structures, and reinforcement bar and wire used in road construction. Surface runoff, vehicle spraying, and windblown actions also affect roadside vegetation, soil, and local surface and ground water supplies. Although there is evidence of environmental loading of salt during peak usage, the spring rains and thaws usually dilute the concentrations of sodium in the area.

Salt also is added to stabilize the soil and to provide firmness to the foundation on which highways are built. The salt acts to minimize the effects of shifting caused by changes in humidity and traffic load in the subsurface.

Distributors.—A tremendous amount of salt is marketed through various distributors, some of which specialize in certain markets such as agricultural and water treatment services. In addition to these two categories, distributor sales include grocery wholesalers and/or retailers, institutional wholesalers, U.S. Government resale, and other wholesalers and retailers.

Other.—The other uses of salt include categories not discussed above.

Stocks

Total yearend stocks reported by producers were estimated to be 3.0 million tons. Most of these inventories were imported rock salt and solar salt. Many salt producers, States, municipalities, distributors, and road-deicing contractors stockpiled additional quantities of salt in anticipation of adverse weather conditions and the inevitable loss of the Retsof rock salt mine. Deicing salt inventories were extremely large by yearend because the mild winter in the domestic snow belt did not require as much salt as had been stockpiled.

Transportation

The locations of the salt supplies often are not in proximity of the consumers location, and transportation can become an important cost. Pumping salt brine through pipelines is an economic means of transportation, but cannot be used for dry salt. Large bulk shipments of dry salt in ocean freighters or river barges are low in cost, but are restricted in points of origin and consumption. River and lake movement of salt in winter is often severely curtained because of frozen waterways. As salt is packaged, handled, and shipped in smaller units, the costs are increased and are reflected in higher selling prices.

Ocean borne imports of salt have been increasing in some areas of the United States because they are less expensive with respect to transportation costs than what could be purchased from many domestic suppliers using rail transportation.

Prices

The four types of salt that are produced each have unique production, processing, and packaging factors that determine the selling prices. Generally, salt sold in bulk is less expensive than salt that has been packaged, pelletized, or pressed. Salt in brine is the least expensive salt sold because mining and processing costs are less. Vacuum pan salt is the most expensive because of the higher energy costs involved in processing and the purity of the product.

Price quotations are not synonymous with average values reported to the USBM. The quotations do not necessarily represent prices at which transactions actually occurred, nor do they represent bid and asked prices. They are quoted here to serve only as a reference to yearend price levels. Yearend prices were quoted in Chemical Marketing Reporter, as shown in table 7. The average annual values, as collected by the USBM, are listed in table 8 and represent a national average value for each of the types of salt and the various product forms. *(See tables 7 and 8.)*

Foreign Trade

Under the Harmonized Tariff Schedule nomenclature, imports only have one category known as "Salt (including table and denatuted salt) and pure sodium chloride, whether or not in aqueous solution, seawater." The same classification also applies to exports. The trade tables in this report list the previous and current identification codes for salt.

Based on Bureau of the Census statistics, the United States in 1994 exported 742,000 tons, an 8% increase compared with that of the previous year. Salt was shipped to 65 countries through 32 U.S. customs districts, of which the Cleveland, OH, district exported the most. In 1994, the majority of exports were to Canada, which was 77% of the total. The Journal of Commerce's Port Import/Export Reporting Service (PIERS), which reports only ocean commerce (no rail or truck traffic between borders with Canada and Mexico) reported that six domestic salt producing companies exported 89% of the 383,000 metric tons exported in 1993. The companies were Akzo Salt Inc., Cargill Salt Co. and its affiliate Leslie Salt Co., North American Salt Co., Morton Salt Co., and Western Salt Co. Therefore, the remaining 12% of exports were conducted by companies that do not produce salt.

The United States imported salt from 30 countries a record 9.63 million tons in 1994, which was 64% more than was imported during the previous year. The high level of imports were to counter the shortage of rock salt resulting from the ultimate closure of the Retsof rock salt mine. The quantity of imports was about 13 times more than the quantity of salt that was exported. Although this would indicate that the United States is import reliant on salt to meet its salt requirements, the majority of imported salt was brought into the country by foreign subsidiaries of major U.S. salt producers. Generally, imported salt can be purchased and delivered to many customers at costs lower than the comparable domestic product because production costs are lower abroad and currency exchange rates are more favorable.

The PIERS service reported that 8.85 million tons were imported; however, PIERS data includes only ocean freight and does not include salt shipped by rail or truck over the U.S. land borders with Canada and Mexico. Therefore, Census data and PIERS Data often are dissimilar. Using PIERS data, Akzo Salt Co., Cargill Inc., Morton International, and North American Salt Co., imported 67% of the total imports. Three companies that manufacture chlorine, which was the single largest domestic salt market, consumed 9% of total imports, which were primarily solar salt. These companies were Atochem North America, Occidental Chemical Corp., and Weyerhaeuser Co. Six salt distributors, Continental Salt Co., Eastern Minerals, Granite State Minerals, Rochez Brothers, Inc., Southern Salt Co., and Quality Salt Sales imported 18% of the total salt. The salt producers, salt distributors, and chloralkali producers imported 94% of total PIERS imports; the remainder were by many small direct buyers. Tables 9 through 12 list the import and export statistics reported by the Bureau of Census for 1993 and 1994. *(See tables 9, 10, 11, and 12.)*

World Review

Table 13 lists world salt production statistics for 110 countries based on reported and estimated information. The unification of the two Germanys and the dissolution of the former U.S.S.R. and Yugoslavia in 1992 have modified the list of nations surveyed. World production decreased less than 1% in 1994 compared with that of the previous year. *(See table 13.)*

Industry Structure

The United States remains the world's leading salt-producing nation, representing about one-fifth of total world production. The structure of the U.S. industry has changed throughout the years. In 1970, there were 50 companies operating 95 plants in the United States. Market competition, energy and labor costs, less expensive imports, and an excess of production capacity resulting in the downsizing of the industry through mergers and acquisitions reduced the size of the industry to 27 companies and 67 plants by 1994.

Most countries possess some form of salt production capability with production levels set to meet their own domestic demand requirements with additional quantities available for export. Many developing nations tend to develop their agricultural resources first to feed their population. Development of easily extractable mineral resources follows with salt being one of the first commodities to be mined. Some countries, such as the United States, import a substantial amount of salt to meet total demand requirements because of economic factors.

Outlook

Despite the loss of the Retsof mine that will occur sometime in the fall of 1995, the United States will continue to have adequate sources of salt to satisfy any demand requirements. The mine accident and the anticipated severe 1993-94 winter caused a surge in imports and an increase in domestic rock salt production in 1994 that contributed to the large buildups of inventories. This will undoubtedly cause domestic production and imports to be less in 1995.

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[1] Chemical Marketing Reporter. Akzo Nobel Combination Looks Like a Perfect Fit. V. 245, No. 16, Apr. 18, 1994, p. 8.

[2] Democrat and Chronicle. Livingston Town Jolted in Tremor. Rochester, NY, Sunday, Mar. 13, 1994, p. 1A.

[3] Industrial Minerals. Flood Closes Akzo Salt Mine. May 1994, No. 320, p. 20-21.

[4] Press Release. Akzo Nobel Salt to Remain in Livingston County. Nov. 2, 1994, 2 pp.

[5] Chemical Week. HoltraChem, Allied Signal Tie Up Hanlin Deal. V. 154, No. 14, Apr. 13, 1994, p. 5.

[6] Chemical Marketing Reporter. Elf Atochem Closes Down Tacoma Chloralkali Facility. V. 245, No. 17, Apr. 25, 1994, p. 4.

[7] U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports, MQ28A, Inorganic Chemicals, First Quarter 1995.

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The Material Flow of Salt, IC 9343, 1993, 32 pp.

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Solution Mining Research Institute.

TABLE 1
SALIENT STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Production - total: 2/	36,800	36,300	36,000	39,200 r/	39,800
Brine	17,400	18,700	17,600	18,100 r/	18,000
Rock	12,800	11,200	11,400	14,300	15,100
Solar	2,990	2,810	3,220	2,960 r/	3,020
Vacuum pan and open pan	3,660	3,650	3,810	3,860	3,700
Sold or used by producers	36,900	35,900	34,800	38,200 r/	39,500
Value	$827,000	$802,000	$803,000	$904,000 r/	$956,000
Exports	2,270	1,780	992	688	742
Value	$32,900	$29,900	$32,200	$34,800	$30,200
Imports for consumption	5,970	6,190	5,390	5,870	9,630
Value	$88,400	$87,400	$87,700	$100,000	$151,000
Consumption, apparent 3/	40,600	40,300	39,200	43,400 r/	48,400
World Production	183,000 r/	185,000 r/	178,000 r/	181,000 r/	180,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes Puerto Rico.

3/ Sold or used plus imports minus exports.

TABLE 2
SALT PRODUCED IN THE UNITED STATES, BY TYPE AND PRODUCT FORM 1/

(Thousand metric tons)

Product form	Vacuum pans and open pans	Solar	Rock	Brine	Total
1993					
Bulk	726	1,860 r/	13,700	18,100 r/	34,500 r/
Compressed pellets	1,020	194 r/	XX	XX	1,210 r/
Packaged	1,830	794 r/	424	XX	3,050 r/
Pressed blocks	292	114 r/	93	XX	500 r/
Total	3,860	2,960 r/	14,300	18,100 r/	39,200 r/
1994					
Bulk	751	1,820	14,300	18,000	34,800
Compressed pellets	864	197	XX	XX	1,060
Packaged	1,830	877	777	XX	3,490
Pressed blocks	252	125	W	XX	420
Total	3,700	3,020	15,100	18,000	39,800

r/ Revised. XX Not applicable. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 3
SALT SOLD OR USED 1/ 2/ IN THE UNITED STATES, BY TYPE AND PRODUCT FORM

(Thousand metric tons and thousand dollars)

Product form	Vacuum pans and open pans		Solar		Rock		Brine		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1993										
Bulk	662	32,800	1,660 r/	27,300 r/	12,800	235,000	18,100 r/	95,000 r/	33,200 r/	390,000 r/
Compressed pellets	967	125,000	194 r/	17,500 r/	NA	XX	XX	XX	1,160 r/	142,000 r/
Packaged:										
Less-than-5-pound units	82	NA	1	NA	--	NA	XX	XX	83	XX
More-than-5-pound units	1,850	NA	848 r/	NA	547	NA	XX	XX	3,250 r/	XX
Total	1,930	241,000	849 r/	48,300 r/	547	35,000	XX	XX	3,330 r/	325,000 r/
Pressed blocks:										
For livestock	108	NA	87 r/	NA	64 r/	NA	XX	XX	259 r/	XX
For water treatment	180	NA	28 r/	NA	21 r/	NA	XX	XX	228	XX
Total	288	28,900	115 r/	10,000 r/	85	8,300	XX	XX	488 r/	47,200 r/
Grand total	3,850	428,000	2,820 r/	103,000 r/	13,400	278,000	18,100 r/	95,000 r/	38,200 r/	904,000 r/
1994										
Bulk	742	37,200	1,690	28,300	14,100	276,000	18,000	97,000	34,600	439,000
Compressed pellets	862	109,000	196	18,900	NA	XX	XX	XX	1,060	128,000
Packaged:										
Less-than-5-pound units	146	NA	110	NA	--	NA	XX	XX	256	XX
More-than-5-pound units	1,680	NA	766	NA	762	NA	XX	XX	3,210	XX
Total	1,820	245,000	876	48,900	762	56,600	XX	XX	3,460	350,000
Pressed blocks:										
For livestock	138	NA	67	NA	42	NA	XX	XX	247	XX
For water treatment	107	NA	57	NA	(3/)	NA	XX	XX	165	XX
Total	245	23,600	124	10,800	42	4,220	XX	XX	412	38,600
Grand total	3,670	415,000	2,890	107,000	14,900	337,000	18,000	97,000	39,500	956,000

r/ Revised. NA Not available. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ As reported at salt production locations. The term "sold or used" indicates that some salt, usually salt brine, is not sold but is used for captive purposes by plant or company. Because data do not include salt imported, purchased, and/or sold from inventory from regional distribution centers, salt sold or used by type may differ from totals shown in tables 5 and 6, which are derived from company totals.

3/ Less than 1/2 unit.

TABLE 4
SALT SOLD OR USED 1/ 2/ BY PRODUCERS IN THE UNITED STATES, BY STATE

(Thousand metric tons and thousand dollars)

State	1993		1994	
	Quantity	Value	Quantity	Value
Kansas 3/	2,280 r/	103,000	2,660	108,000
Louisiana	12,400	115,000	13,500	140,000
New York	5,620	191,000	6,060	233,000
Texas	8,360 r/	76,900 r/	8,040	70,500
Utah	1,680 r/	57,200 r/	1,680	56,700
Other Eastern states 4/	6,050	295,000	6,130	280,000
Other Western states 5/	1,840 r/	65,700	1,470	67,800
Total	38,200 r/	904,000 r/	39,500	956,000
Puerto Rico	45	1,500	45	1,500

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The term "sold or used" indicates that some salt, usually salt brine, is not sold but is used for captive purposes by plant or company.

3/ In 1993 the quantity and value of brine for Kansas was included with "Other Western States ." In 1994 brine was included in the quantity and value of all salt produced in Kansas.

4/ Includes Alabama, Michigan, Ohio, and West Virginia.

5/ Inludes Arizona, California, Kansas (brine only 1993) Nevada, New Mexico, and Oklahoma.

TABLE 5
DISTRIBUTION OF DOMESTIC AND IMPORTED 1/ 2/ DATA BY PRODUCERS IN THE UNITED STATES BY END USE AND TYPE

(Thousand metric tons)

End use	Standard industrial classification	Vacuum pans and open pans		Solar		Rock		Salt in brine		Grand total 3/	
		1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Chemical:											
Chloralkali producers	2812	35	36	135 r/	228	421	770	16,900	16,200	17,500	17,300
Other chemical	28 '(excludes 2812, 2899)	475	401	395 r/	299	916 r/	384	79	17	1,870 r/	1,100
Total		509	437	531 r/	528	1,340 r/	1,160	16,900	16,200	19,300	18,400
Food-processing industry:											
Meat packers	201	226	226	63 r/	65	129	119	--	(4/)	418 r/	410
Dairy	202	107	110	6	6	3	3	1	--	117	117
Canning	2091, 203	171	196	81	81	69	62	1	2	322	342
Baking	205	139	142	2	2	11	13	--	--	152	157
Grain mill products	204 (excludes 2047	101	102	11 r/	17	55	54	--	--	167 r/	175
Other food processing	206-208, 2047, 2099	221	237	25 r/	29	31	31	(4/)	(4/)	278 r/	297
Total		964	1,010	188 r/	201	298	282	3	2	1,450 r/	1,500
General Industrial:											
Textiles and dyeing	22	235	226	46	53	27	20	5	5	313	304
Metal processing	33, 34, 35, 37	10	11	27 r/	30	180 r/	198	--	--	216 r/	239
Rubber	2822, 30 (excludes 3079)	2	3	1	1	6	4	28	25	37	33
Oil	13, 29	24	37	239 r/	209	115 r/	80	847	960	1,220 r/	1,290
Pulp and paper	26	18	15	44	52	41 r/	76	8	7	110 r/	150
Tanning and/or leather	311	10	10	27 r/	35	30	37	--	--	67 r/	82
Other industrial	9621	53	59	238 r/	236	196 r/	223	3	3	490 r/	521
Total		352	360	620 r/	615	593 r/	638	891	1,000	2,460 r/	2,610
Agricultural:											
Feed retailers and/or dealers- mixers	434	221	227	393 r/	357	504 r/	490	(4/)	--	1,120 r/	1,070
Feed manufactuers	2048	67	66	101 r/	87	307	324	(4/)	(4/)	476 r/	478
Direct-buying end user	02	8	9	11 r/	12	30 r/	37	--	(4/)	49 r/	58
Total		297	301	505 r/	456	843 r/	851	(4/)	(4/)	1,650 r/	1,610
Water Treatment:											
Government (Federal, State, local)	2899	17	18	119	70	107	122	3	3	246	213
Commercial or other	2899	14	18	63	71	97	132	1	7	175	227
Total		31	36	181	141	203	253	4	10	419	440
Ice control and/or stabilitation:											
Government (Federal, State, local)	9621	1	4	407	1,070	12,200 r/	13,900	10	10	12,700 r/	15,000
Commercial or other	5159	2	2	53 r/	111	840 r/	1,310	1	--	896 r/	1,430
Total		4	5	460 r/	1,180	13,100 r/	15,200	12	10	13,600 r/	16,400

TABLE 5-Continued
DISTRIBUTION OF DOMESTIC AND IMPORTED 1/ 2/ DATA BY PRODUCERS IN THE UNITED STATES BY END USE AND TYPE

(Thousand metric tons)

End use	Standard industrial classification	Vacuum pans and open pans		Solar		Rock		Salt in brine		Grand total 3/	
		1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Distributors:											
Agricultural distribution	5191	326 r/	320	191 r/	208	290 r/	314	(4/)	--	808 r/	842
Grocery wholesalers and/or retailers	514, 54	506	525	230 r/	297	86 r/	112	--	--	823 r/	934
Institutional wholesalers and end users	58, 70	80	82	29	29	30	33	(4/)	(4/)	139	144
Water-conditioning distribution	7399	125 r/	131	336 r/	309	66 r/	65	--	--	527 r/	505
U.S. Government resale	9199	1	1	3 r/	5	2 r/	8	--	--	5 r/	13
Other wholesalers and/or retailers	5251	649 r/	711	639 r/	665	732 r/	968	(4/)	(4/)	2,020 r/	2,340
Total		1,690 r/	1,770	1,430 r/	1,510	1,210 r/	1,500	(4/)	1	4,320 r/	4,780
Other n.e.s. 5/		277	199	225 r/	253	592 r/	869	148	150	1,250 r/	1,470
Grand Total		4,130	4,120	4,140 r/	4,890	18,200 r/	20,700	18,000	17,400	44,400 r/	47,200

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ The quality of imports included in the total for each type of salt is the amount reported by the U.S. salt industry, not the quantity reported by the U.S. Bureau of the Census that appears in tables 1, 11 and 12.

3/ Because data include salt imported, produced, and/or sold from inventory from regional distribution centers, salt sold or used by type may differ from totals shown in tables 1, 3, and 4, which are derived from plant reports at salt production locations. Data may differ from totals show in table 6 because of changes in inventory and/or incomplete data reporting.

4/ Less than 1/2 unit.

5/ Includes exports.

TABLE 6
DISTRIBUTION OF DOMESTIC AND IMPORTED EVAPORATED AND ROCK SALT 1/ 2/ IN THE UNITED STATES, BY DESTINATION

(Thousand metric tons)

Destination	1993				1994			
	Evaporated				Evaporated			
	Vacuum pans and open pans	Solar	Rock	Total	Vacuum pans and open pans	Solar	Rock	Total
Alabama	58	1	84	143	56	(3/)	92	149
Alaska	(3/)	5	--	5	(3/)	4	(3/)	4
Arizona	9	101 r/	60	173	11	90	2	102
Arkansas	43	3	72	118	42	3	87	132
California	141	806 r/	2	950 r/	145	758	2	905
Colorado	12	189 r/	48	247 r/	12	76	52	140
Connecticut	12	8	219	239	14	13	230	257
Delaware	3	38	16	57	3	31	29	62
District of Columbia	1	1	19	21	1	15	11	27
Florida	76 r/	134	27	237 r/	75	150	34	258
Georgia	85	35	68	188	69	49	57	175
Hawaii	2	3	1	6	1	3	--	4
Idaho	6	85	(3/)	91	8	84	1	93
Illinois	330 r/	102 r/	1,720 r/	2,150 r/	333	167	1,920	2,420
Indiana	195	72 r/	677 r/	945 r/	217	79	859	1,160
Iowa	178 r/	81 r/	496 r/	755 r/	180	69	469	718
Kansas	98 r/	64	434	595 r/	75	36	536	422
Kentucky	60	5	356 r/	420 r/	56	5	529	590
Louisiana	39	1	356 r/	397 r/	45	2	367	413
Maine	8	19	258	285	8	29	250	288
Maryland	77	173	139	389	76	447	227	750
Massachusetts	26	8	673	707	33	25	568	626
Michigan	240	26	1,520 r/	1,780 r/	248	28	1,720	2,000
Minnesota	132	191 r/	582 r/	902 r/	139	182	513	834
Mississippi	20	(3/)	207 r/	227 r/	23	(3/)	237	261
Missouri	166	37 r/	540 r/	742 r/	129	44	576	749
Montana	1	45 r/	3	48 r/	1	44	3	48
Nebraska	73	30	245	348	75	38	159	272
Nevada	2	203 r/	W	228 r/	2	237	11	251
New Hampshire	4	4	214	222	5	4	102	111
New Jersey	125	145	338	608	131	234	523	889
New Mexico	7	48	--	55	6	49	1	55
New York	144	52	2,560 r/	2,760 r/	206	164	3,170	3,540
North Carolina	264	42	85 r/	390 r/	218	68	105	390
North Dakota	11	27 r/	18	57 r/	5	28	9	43
Ohio	349	33	1,640 r/	2,010 r/	368	45	2,090	2,500
Oklahoma	31	16	78 r/	126 r/	31	19	61	111
Oregon	12	43 r/	1	56 r/	13	130	131	274
Pennsylvania	180	132	1,360 r/	1,670 r/	217	187	1,900	2,310
Rhode Island	10	7	50	67	8	10	101	119
South Carolina	43	8	12	63	49	7	12	67
South Dakota	32	46 r/	47	126 r/	31	53	26	110
Tennessee	75	2	529 r/	605 r/	71	3	579	653
Texas	181 r/	139	320	635	183	137	258	578
Utah	6	428 r/	W	434 r/	7	347	W	354
Vermont	5	1	179	185	5	1	254	261
Virginia	100	49	160	309	95	161	193	449
Washington	23	279 r/	(3/)	303 r/	26	240	(3/)	266
West Virginia	13	3	128	144	12	3	183	199
Wisconsin	227	88 r/	1,070 r/	1,380 r/	230	104	1,180	1,510
Wyoming	(3/)	20 r/	2	22 r/	(3/)	25	2	27
Other 4/	208	64 r/	319 r./	592 r/	128	161	302	592
Total 5/	4,130	4,140 r/	18,200 r/	26,200 r/	4,120	4,890	20,700	29,500

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Each salt type includes domestic and imported quantities. Brine is excluded because brine is not shipped out of State.

3/ Less than 1/2 unit.

4/ Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and shipments to States indicated by symbol W.

5/ Because data include salt imported, purchased and/or sold from inventory from regional distribution centers, evaporated and rock salt distributed by State may differ from totals shown in tables 1 and 3, which are derived from plant reports at salt production locations. Data may differ from totals shown in table 5 because of changes in inventory and/or incomplete data reporting.

TABLE 7
SALT YEAR END PRICES

	1993	1994
Salt, evaporated, common:		
80-pound bags, carlots or truckloads:		
North, works, 80 pounds	$4.02	$4.02
Bulk, same basis, per ton	60.00-61.20	60.00-61.20
Salt, chemical grade, same basis:		
North, works, 80 pounds	4.30	4.30
Salt, rock, medium, coarse:		
Same basis, 80 pounds	2.70	2.70
Bulk, same basis, per ton	18.00-25.00	18.00-25.00
Sodium chloride, U.S.P.:		
Granular bags, per pound	.29	.29

Sources: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials, v. 245, No. 1, Jan. 3, 1994, p 30; and v. 247, No. 1, Jan. 2, 1995, p. 32.

TABLE 8
AVERAGE VALUE 1/ OF SALT, BY PRODUCT FORM AND TYPE

(Dollars per metric ton)

Product form	Vacuum pans and open pans	Solar	Rock	Brine
1993				
Bulk	49.63 r/	16.48 r/	18.40	5.24 r/
Compressed pellets	129.16	90.48 r/	XX	XX
Packaged	124.72 r/	56.90 r/	64.07	XX
Average 2/	111.97 r/	34.51 r/	20.28 r/	5.24 r/
Pressed blocks	100.38	86.76 r/	97.55 r/	XX
1994				
Bulk	50.14	16.74	19.54	5.40
Compressed pellets	126.85	96.06	XX	XX
Packaged	134.34	55.85	74.26	XX
Average 2/	114.24	34.77	22.33	5.40
Pressed blocks	96.11	87.38	99.27	XX

r/ Revised. XX Not applicable.

1/ Net selling value, f.o.b. plant, excluding container costs.

2/ Salt value data previously reported were an aggregate value per ton of bulk, compressed pellets, and packaged salt. For time series continuity, an average of these three types of product forms is presented, which is based on the aggregated values and quantities of the product form for each type of salt shown in table 3.

TABLE 9
U.S. EXPORTS OF SALT, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	Value	Quantity	Value
Argentina	(2/)	30	2	63
Australia	2	87	(2/)	16
Bahamas, The	2	138	1	185
Bahrain	1	299	3	352
Belize	(2/)	9	(2/)	4
Brazil	(2/)	15	1	57
Canada	499	20,400	573	20,300
Chile	1	29	(2/)	21
Costa Rica	1	28	(2/)	33
Dominican Republic	(2/)	87	(2/)	100
El Salvador	5	440	1	132
France	(2/)	56	1	29
Germany	2	69	2	68
Guatemala	1	96	(2/)	11
Honduras	3	181	1	74
Hong Kong	(2/)	65	(2/)	72
Ireland	(2/)	26	(2/)	20
Jamaica	2	154	2	152
Japan	11	644	4	225
Korea, Republic of	32	2,080	1	362
Mexico	66	3,860	80	3,040
Netherlands	(2/)	7	(2/)	21
Netherlands Antilles	(2/)	65	(2/)	76
Panama	2	187	3	342
Saudi Arabia	29	3,380	21	1,870
Taiwan	8	705	4	177
Trinidad and Tobago	(2/)	5	(2/)	7
United Arab Emirates	1	282	1	210
United Kingdom	1	131	2	231
Venezuela	1	24	2	58
Other	16	1,220	37	1,910
Total	688	34,800	742	30,200

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 10
U.S. EXPORTS OF SALT, BY CUSTOMS DISTRICT 1/

(Thousand metric tons and thousand dollars)

	1993		1994	
Country	Quantity	Value	Quantity	Value
Anchorage, AK	27	410	(2/)	4
Baltimore, MD	10	1,420	6	829
Boston, MA	--	--	(2/)	14
Buffalo, NY	12	1,580	62	2,790
Charleston, SC	(2/)	7	(2/)	26
Chicago, IL	(2/)	13	(2/)	43
Cleveland, OH	276	6,580	290	5,600
Columbia-Snake, OR	(2/)	77	(2/)	10
Detroit, MI	63	3,660	50	3,530
Duluth, MN	(2/)	24	(2/)	22
El Paso, TX	1	126	3	132
Great Falls, MT	2	223	4	275
Houston, TX	11	903	28	1,520
Laredo, TX	61	2,520	72	2,620
Los Angeles, CA	36	2,180	10	827
Miami, FL	5	360	5	528
Mobile, AL	1	135	(2/)	62
New Orleans, LA	15	1,940	7	694
New York, NY	4	285	12	735
Nogales, AZ	1	65	3	149
Norfolk, VA	7	1,430	3	492
Ogdensburg, NY	4	454	24	861
Pembina, ND	1	207	1	166
Philadelphia, PA	(2/)	37	(2/)	44
St. Albans, VT	--	--	(2/)	3
St. Louis, MO	(2/)	56	(2/)	26
San Diego, CA	1	259	2	139
San Francisco, CA	28	1,210	38	1,120
San Juan, PR	(2/)	26	(2/)	5
Savannah, GA	7	1,130	2	326
Seattle, WA	13	1,010	18	623
Tampa, FL	(2/)	33	1	50
Other 3/	100	6,450	99	5,930
Total	688	34,800	742	30,200

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Unknown, but assumed to be rail and/or truck shipments to Canada through various points of entry.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF SALT, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Bahamas, The	807	11,300	1,180	16,700
Brazil	106	1,200	220	2,480
Canada	3,100	53,000	3,660	67,700
Chile	192	4,180	1,920	23,000
France	3	599	1	635
Germany	3	536	2	428
Italy	1	70	37	778
Korea, Republic of	3	564	3	633
Mexico	1,340	20,900	2,120	30,700
Netherlands	176	4,140	70	1,510
Netherlands Antilles	93	1,710	212	3,810
Spain	16	531	188	1,740
United Kingdom	2	113	14	216
Other	23 r/	1,030 r/	7	1,010
Total	5,870	100,000	9,630	151,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS OF SALT, BY CUSTOMS DISTRICT 1/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	Value	Quantity	Value
Anchorage, AK	--	--	3	119
Baltimore, MD	344	6,610	1,170	18,600
Boston, MA	295	5,830	474	10,900
Buffalo, NY	4	363	46	1,820
Charleston, SC	94	1,970	87	1,830
Chicago, IL	575	9,470	535	10,700
Cleveland, OH	127	2,410	89	2,190
Columbia-Snake, OR	363	4,210	357	4,280
Dallas-Fort Worth, TX	--	--	(2/)	2
Detroit, MI	873	15,800	1,190	23,200
Duluth, MN	175	2,470	159	2,550
El Paso, TX	(2/)	3	(2/)	2
Great Falls, MT	(2/)	17	1	71
Honolulu, HA	(2/)	30	(2/)	2
Houston, TX	(2/)	23	(2/)	72
Los Angeles, CA	119	2,080	114	2,150
Miami, FL	(2/)	43	(2/)	27
Milwaukee, WI	748	13,700	682	12,700
Minneapolis, MN	20	334	--	--
New Orleans, LA	176	2,440	223	3,020
New York, NY	235	5,380	1,650	21,100
Norfolk, VA	19	288	175	2,490
Ogdensburg, NY	49	915	95	3,770
Pembina, ND	12	379	20	443
Philadelphia, PA	329	4,720	752	8,530
Portland, ME	356	5,160	595	7,870
Providence, RI	70	782	202	2,090
St. Albans, VT	(2/)	12	8	453
St. Louis, MO	(2/)	26	(2/)	13
San Diego, CA	(2/)	46	(2/)	40
San Francisco, CA	(2/)	42	(2/)	80
San Juan, PR	16	595	22	787
Savannah, GA	83	1,390	41	572
Seattle, WA	454	6,940	374	5,140
Tampa, FL	209	3,090	197	2,860
Washington, DC	(2/)	3	--	--
Wilmington, NC	120	2,420	95	830
Total	5,870	100,000	9,630	151,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 13
SALT: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Afghanistan (rock salt) e/	10	12	12	13	13
Albania e/	85 4/	55	5	10	10
Algeria	222	211	210 e/	210 e/	210
Angola e/	30 r/	40 r/	20 r/	30 r/	30
Argentina:					
Rock salt e/	1	(5/) r/	(5/) r/	1 r/	1
Other salt	833 r/	943 r/	952 r/	1,030 r/	1,000
Total e/	834	943	952	1,030	1,000
Armenia e/	XX	XX	100	50	40
Australia (brine salt and marine salt)	7,230	7,790	7,690 r/	7,740 r/	7,800
Austria:					
Brine salt	674	698	662	695 r/	700
Rock salt	1	1	1 e/	1 e/	1
Total	675	699	663 e/	696 e/	701
Azerbaijan e/	XX	XX	50	40	30
Bahamas, The	828	1,100	809	850 e/	900
Bangladesh (marine salt) e/ 6/	350 4/	300	320	340	350
Belarus e/	XX	XX	360	300	250
Benin (marine salt) e/	(5/)	(5/)	(5/)	(5/)	(5/)
Bolivia	(5/)	(5/)	(5/) e/	(5/) e/	(5/)
Bosnia and Herzegovina e/	XX	XX	70	50	50
Botswana 7/	--	3	54	98 r/	100
Brazil:					
Marine salt	4,170	3,700	4,030 r/	4,000 r/	4,000
Rock salt	1,200 r/	1,200 r/	1,230 r/	1,250 r/	1,250
Total	5,370	4,900	5,260	5,250	5,250
Bulgaria e/	93 4/	90	90	80	80
Burkina Faso e/	7	7	7	7	7
Burma e/ 8/	260	260	260	260	260
Cambodia e/	40	40	40	40	40
Canada	11,300	12,000	11,200	10,900 r/	11,500 4/
Cape Verde e/	4	4	4	4	4
Chile	1,840	1,680	1,670	1,440 r/	1,500
China e/	20,000	24,100	28,100	29,500	29,700
Colombia:					
Marine salt	478	482	317	169 r/	170
Rock salt	209	219	230	231 r/	230
Total	687	701	547	400	400
Costa Rica (marine salt) e/	40	50	50	45	45
Croatia	XX	XX	40 r/	23 r/	25
Cuba e/	200	200	185	185	175
Czech Republic e/	XX	XX	XX	180	180
Czechoslovakia 9/	227	207	200 e/	XX	XX
Denmark (sales)	522	550	528	591 r/	600
Dominican Republic (rock salt)	11	11	12 e/	12	10
Egypt (marine salt)	989	891	890 e/	972 r/	972
El Salvador (marine salt)	8	15	20 e/	20 e/	20
Eritrea: e/ 10/					
Marine salt	XX	XX	XX	25	50
Rock salt	XX	XX	XX	1	2
Total	XX	XX	XX	26	52
Ethiopia: e/ 6/					
Marine salt	100	85	70 r/	45 r/	20
Rock salt	10	8	6 r/	3 r/	2
Total	110	93	76	48	22
France:					
Brine salt	1,160	1,000 e/	1,650	1,310 r/	1,400
Marine salt	1,300	1,200 e/	1,160	1,200 e/	1,200
Rock salt e/	790	800	103 4/	116 r/	120
Salt in solution	3,360	3,500 e/	3,210	2,630 r/	2,720
Total e/	6,610	6,500	6,120 4/	5,260	5,440

See footnotes at end of table.

TABLE 13--Continued

SALT: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Germany:					
Marine salt:					
Eastern states	45	XX	XX	XX	XX
Western states	785	XX	XX	XX	XX
Total marine	830	563 r/	571 r/	558 r/	575
Rock salt and other:					
Eastern states	4,080	XX	XX	XX	XX
Western states	10,800	XX	XX	XX	XX
Total rock and other	14,900	14,300 r/	12,100 r/	12,100 r/	12,100
Total	15,700	14,900	12,700	12,700	12,700
Ghana e/	50	50	50	50	50
Greece e/	150 4/	150	125	100	100
Guatemala e/	181 4/	100	100	100	100
Honduras e/	30	30	30	30	25
Iceland e/	3	3	4 4/	5	5
India: e/					
Marine salt	9,500	9,500	9,500	9,500	9,500
Rock salt	3	3	3 4/	3 r/ 4/	3
Total	9,500	9,500	9,500	9,500	9,500
Indonesia e/	600	610	630	650	650
Iran 11/	848	901	1,110	720 r/	900
Iraq e/	250	120	250	300	300
Israel	426	1,120	1,100	1,120 r/	1,120
Italy:					
Brine salt and rock salt	3,750	3,500	3,210	2,490 r/	2,500
Marine salt, crude e/ 12/	680	450	610 r/	580 r/	600
Total e/	4,430	3,950	3,820	3,070	3,100
Jamaica	12	14 r/	14	14	14
Japan	1,380	1,380	1,410	1,380 r/	1,390
Jordan	55	57	56	26 r/	26
Kenya (crude salt)	102	102 e/	102 e/	75 r/	75
Korea, North e/	580	580	590	590	600
Korea, Republic of	617	696	772	750 e/	760
Kuwait	30 e/	--	15 e/	30	30
Laos (rock salt) e/	8	8	8	8	8
Lebanon e/	3	3	3	3	3
Leeward and Windward Islands e/	5	5	1	1	1
Libya e/	12	12	12	12	12
Madagascar e/	30	30	30	30	30
Mali e/	5	5	5	5	5
Malta (marine salt) e/	(5/) 4/	(5/)	(5/)	(5/)	(5/)
Martinique e/	200	200	200	200	200
Mauritania e/	6	6	6	6	6
Mauritius e/	6	6	6	6	6
Mexico	7,140	7,530	7,400	7,490 r/	7,460 4/
Mongolia e/	17	17	17	18	18
Morocco (rock salt)	125	109	165	170 r/	170
Mozambique (marine salt) e/	40	40	40	40	40
Namibia (marine salt) 13/	157	141	115	116 r/	400
Nepal 14/	7	7	7	7	7
Netherlands	3,650	3,420	3,630	3,500 e/	3,500
Netherlands Antilles e/	350	350	350	300	350
New Zealand e/	80	80	80	80	80
Nicaragua (marine salt) e/	15	15	15	15	15
Niger e/	3 4/	3	3	3	3
Pakistan: 6/					
Marine salt	14	12	10	14 r/	13
Rock salt	763	769	853	895 r/	900
Total	777	781	863	909	913
Panama (marine salt) e/	22	18	20	20	20
Peru e/	200	200	238 4/	238	238
Philippines (marine salt)	490	493	496	535 r/	540

See footnotes at end of table.

TABLE 13--Continued
SALT: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Poland:					
Rock salt	556	556	582	718 r/	700
Other salt	3,500	3,280	3,310	3,100 r/	3,100
Total	4,060	3,840	3,890	3,820	3,800
Portugal:					
Marine salt e/	125	125	125	125	125
Rock salt	523	525	592 r/	580 r/	560
Total e/	648	650	717	705	685
Romania:					
Rock salt e/	2,000	1,000	900 4/	900	900
Other salt	2,260	3,000 e/	1,590	1,500 e/	1,500
Total e/	4,260	4,000	2,490 4/	2,400	2,400
Russia e/	XX	XX	4,000	3,500	3,000
Senegal e/	92	102	110	117 r/	117
Serbia and Montenegro	XX	XX	47	39 r/	32 4/
Sierra Leone e/	200	200	200	200	200
Slovakia e/	XX	XX	XX	70	70
Slovenia e/	XX	XX	8	8	8
Somalia e/	2	1	1	1	1
South Africa, Republic of 13/	728	665	702	613 r/	282 4/
Spain:					
Marine salt and other evaporated salt e/	858 4/	900	900	900	900
Rock salt	2,520	2,500 e/	2,870 e/	2,510 r/	2,500
Total e/	3,380	3,400	3,770	3,410	3,400
Sri Lanka	53	53	122	43 r/	50
Sudan e/	68 4/	75	75	75	75
Switzerland	254	250 e/	276	300 e/	300
Syria e/	127 4/	127	127	127	127
Taiwan (marine salt)	83	195	26	176 r/	195
Tanzania	39	64	64 e/	64 e/	64
Thailand:					
Rock salt	119	125	213	262 r/	230
Other e/	100	100	100	100	100
Total e/	219	225	313	362	330
Tunisia (marine salt)	402	441	460	435 r/	435
Turkey	1,890	1,440	1,420	1,430	1,400
Uganda e/	5	5	5	5	5
U.S.S.R. 15/	14,700	14,000 e/	XX	XX	XX
Ukraine e/	XX	XX	4,400	4,000	3,500
United Kingdom:					
Brine salt 16/	1,340	1,320	1,200 e/	1,200 e/	1,300
Rock salt	1,100	1,640	1,500 e/	1,500 e/	1,200
Other salt 16/	3,990	3,870	3,400	3,500 e/	3,200
Total	6,430	6,830	6,100 e/	6,200 e/	5,700
United States including Puerto Rico:					
United States:					
Brine	17,700	18,600	17,600	18,100 r/	18,000 4/
Rock salt	13,100	11,100	10,900	14,300 r/	15,100 4/
Solar salt	2,480	2,580	2,540	3,540 r/	3,020 4/
Vacuum pan salt	3,660	3,620	3,760	3,860 r/	3,700 4/
Puerto Rico e/	41	41	45 4/	45	45
Total e/	37,000	35,900	34,800 4/	39,800	39,800
Venezuela	439	430	318	370 r/ e/	400
Vietnam e/	340	350	350	350	375
Yemen e/	220 4/	250	280	280	280
Yugoslavia: 17/					
Brine salt	204	220 e/	XX	XX	XX
Marine salt	71	70 e/	XX	XX	XX
Rock salt	100	100 e/	XX	XX	XX
Total	375	390 e/	XX	XX	XX
Grand total	183,000 r/	185,000 r/	178,000 r/	181,000 r/	180,000

See footnotes at end of table.

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 5, 1995.

3/ Salt is produced in many other countries, but quantities are relatively insignificant and reliable production data are not available. Some salt brine production data for manufacture of chlorine, caustic soda, and soda ash are not reported because of incomplete data reporting by many countries.

4/ Reported figure.

5/ Less than 1/2 unit.

6/ Year ending June 30 of that stated.

7/ From natural soda ash production.

8/ Brine salt production as reported by the Burmese Government in metric tons, was as follows: 1990--49,700; 1991--46,800; 1992--46,500 ; 1993--58,900 (revised); and 1994--58,000 (estimated).

9/ Dissolved Dec. 31, 1992.

10/ Eritrea production was included in Ethiopia until independence in May 1993.

11/ Year begining Mar. 21 of that stated.

12/ Does not include production from Sardinia and Sicily, estimated at 200,000 metric tons annually.

13/ The Republic of South Africa's decline and Namibia's increase in 1994 are due to production from Walvis Bay now included under Namibia.

14/ Year ending July 15 of that stated.

15/ Dissolved in Dec. 1991.

16/ Data captioned "Brine salt" for the United Kingdom are the quantities of salt obtained from the evaporation of brines; that captioned "Other salt" is the salt content of brines used for purposes other than production of salt.

17/ Dissolved in Apr. 1992.

CONSTRUCTION SAND AND GRAVEL

By Wallace P. Bolen

Construction sand and gravel is one of the most accessible natural resources and a major basic raw material used mostly by the construction industry. Despite the relative low value of its basic products, the construction sand and gravel industry is a major contributor to and an indicator of the economic well-being of the Nation.

A total of 891 million metric tons of construction sand and gravel was produced in the United States in 1994, a 2.5% increase compared with the estimated total of 1993, and a 6.8% increase over the actual total of 1992. After a decrease in production in 1991, sand and gravel production has had healthy increases for three consecutive years, an indication of continuous strong demand for construction aggregates in the United States. *(See table 1.)*

Foreign trade of construction sand and gravel remained relatively minor in 1994. Exports decreased 7.5% to 1.05 million tons, but the value increased 30% to $20.3 million, compared with 1993.

Imports increased nearly 14% to 1.5 million tons, but the value decreased almost 4% to $14.8 million. Because imports and exports are relatively tiny, domestic apparent consumption of construction sand and gravel is essentially equal to U.S. production of 891 million tons.

The major issues of concern to the construction sand and gravel industry are: the implementation of the Clean Air Act Amendments of 1990 and its complex legal and technical provisions; the amended Federal Water Pollution Control Act of 1977, the Clean Water Act, Section 404, dealing with "wetlands" and the associated "no net loss of wetlands" policy; the Storm Water Pollution Prevention Program; the Occupational Safety and Health Administration's (OSHA) Hazard Communication Standards regulating the use of products containing more than 0.1% crystalline silica; and the provisions of the Federal Endangered Species Act.

Production

U.S. production of construction sand and gravel was 891 million tons in 1994. Of the four major geographic regions, the West again led the Nation in the production of construction sand and gravel with 314 million tons, or 35% of the U.S. total, followed by the Midwest with 287 million tons, or 32% of the total; the South with 194 million tons, or 22%; and the Northeast with 97 million tons, or 11%. Compared with 1993, production by major geographic regions increased 5% in the Midwest, 3.5% in the Northeast, 3% in the West, and was unchanged in the South. *(See table 2.)*

Of the nine geographic regions, the East North Central led the Nation in the production of construction sand and gravel with 192 million tons, or 21.5% of the U.S. total, followed by the Pacific with 171 million tons, or 19.2%; and the Mountain with 143 million tons, or 16.2% of the total. *(See table 2.)* Compared with 1993, production increased in all but three regions. The regions with decreases were the Mountain, 4.6%; the Middle Atlantic, 2.4%; and the South Atlantic, 9.8%.

A review of the production by size of operation indicates that 42.8% of the construction sand and gravel produced in 1994 came from 1,847 operations reporting between 100,000 and 499,999 tons per year; 25% came from 360 operations reporting between 500,000 and 999,999 tons per year; and 19.3% came from 115 operations reporting over 1,000,000 tons per year. A total of 6,020 operations were active in 1994. *(See table 8.)*

The estimated production by quarters for 1994 indicates that most of the construction sand and gravel in the United States was produced in the third quarter, followed by the second quarter and the fourth quarter. *(See table 3.)* Estimated production by each quarter of 1994 was also available for most of the States. *(See table 5.)*

Construction sand and gravel was produced in 1994 in every State. The 10 leading States in descending order of tonnage were, California, Texas, Michigan, Ohio, Washington, Illinois, Arizona, Minnesota, Wisconsin, and Colorado. Their combined production represented 50.4% of the national total. Compared with 1993, production increased in 31 States, including 7 of the top 10 States. *(See table 4.)*

Limited information about the production of construction sand and gravel in foreign countries may be found in the U.S. Bureau of Mines "Minerals Yearbook, Volume III, Area Reports: International." For nonreporting countries, estimates of sand and gravel and crushed stone outputs can be based on indirect sources such as the level of cement consumption.

In an industry with thousands of operating companies, status and ownership changes are many. Although it is not possible to review them all, a few noteworthy events will be covered.

LaFarge Corp. announced at the beginning of 1994 a restructuring to increase its cost competitiveness. The restructuring, into three North American regions, was implemented in order to improve organizational efficiency by reducing management layers, eliminating duplicative administrative functions, and standardizing procedures and information systems.

Lone Star Industries, which filed for bankruptcy under Chapter 11 in 1990, had its reorganization approved by a judge in late February. Some assets were retained and others were turned over to a liquidating company to help pay creditors and stockholders. In August, Lone Star was reported to be selling its RMC Lonestar plant in Santa Cruz, CA, to the U.K.-based RMC.

In March, Financial Times reported that British-based English China Clays (ECC) bought Kost Brothers, an aggregate producer near Fargo, ND. In May, ECC announced plans to demerge its construction materials division and form a new company called CAMAS plc. This new company will encompass all former ECC construction materials companies. In September, it was announced that CAMAS had acquired C&M Ready Mix Concrete of Boulder, CO, which includes 12 million tons of proven aggregate reserves.

In other news, Tarmac America announced a major reorganization in April. Tarmac America will be organized into three groups: Aggregates and Cement, Ready-Mix Concrete, and Concrete Products. Also, Tarmac America has moved its headquarters to Norfolk, VA.

Another large producer, Dravo Corp., decided in June to consolidate two divisions, Dravo Basic Materials Co. and Dravo Lime Co., into a single unit. The consolidations were taken after the company reported a first-quarter loss of $2.6 million.

British-based Bruntcliffe Aggregates PLC acquired Culpeper Stone Co., Culpeper, VA, in August. The operations will be known as Atlantic States Materials Corp. Culpeper operated two sand and gravel and three ready-mix concrete operations.

In September, Martin Marietta Materials (MMM) announced its plans to purchase Dravo Corp.'s construction aggregates business. Dravo operated 22 production facilities and MMM operated quarries in 13 states. MMM also acquired a quartzite sand quarry at Cummings, GA, from Buckhorn Minerals.

Meridian Aggregates Co. has purchased the assets of the Hatton, AR, quarry from Herzog Stone Products.

Consumption

Construction sand and gravel reported by producers to the U.S. Bureau of Mines (USBM) is actually material that was "sold or used" by the companies and is defined as such. Stockpiled production is not reported until it is sold to a user or consumed by the producer. Because no consumption surveys are conducted by the USBM, the "sold or used" tonnage is assumed to represent the amount produced for domestic consumption and export. Because some of the construction sand and gravel producers did not report a breakdown by end use, their total production is reported under "Unspecified uses, actual." The estimated production of nonrespondents is reported under "Unspecified uses, estimated."

Of the 891 million tons of construction sand and gravel produced in 1994, 316 million tons or 35.5% of the total were unspecified uses. Of the remaining 575 million tons, 42.1% was used as concrete aggregates; 23.8% for road base and coverings and road stabilization; 14% as asphaltic concrete aggregates and other bituminous mixtures; 13.1% as construction fill; 2.1% for concrete products such as blocks, bricks, pipes, etc.; 1.3% for plaster and gunite sands; and the remainder for snow and ice control, railroad ballast, roofing granules, filtration, and other miscellaneous uses. *(See table 6.)*

To provide a more accurate estimation of the consumption patterns for construction sand and gravel, the "Unspecified uses" are not included in the above percentages. It is recommended that in any marketing or use pattern analysis the quantities included in "Unspecified uses" be distributed among the reported uses by applying the above percentages.

A review of consumption by major geographic regions indicates that most of the sand and gravel for concrete aggregates including concrete sand, was used in the South, 32.4%; the West, 31.9%; and the Midwest, 26%; regions with high levels of construction activity. Most of the sand and gravel for road base and coverings was used in the West, 45.5%; and the Midwest, 36.1%; while most of the sand and gravel used for asphaltic concrete aggregates and other bituminous mixtures was used in the West, 38.3%; and the Midwest, 33%. *(See table 7.)*

Additional information regarding production-consumption of construction sand and gravel by major uses in each State and the State districts is published in the U.S. Bureau of Mines Minerals Yearbook State chapters, Volume II of the U.S. Bureau of Mines Minerals Yearbook.

Transportation

Information regarding the method of transportation of construction sand and gravel from the pit or processing plant to the first point of sale or use is now available for each geographic region as well as total U.S. Reports regarding the method of transportation were provided by the producers for 549 million tons or 61.6% of the total U.S. production of construction sand and gravel. Of this total, 76.1% was transported by truck, 3.3% by waterway, and 1.3% by rail. A significant amount of construction sand and gravel produced, about 18.8%, was not transported and used at the production site. *(See table 11.)* Because most producers either did not keep records or did not report shipping distances or cost per ton per mile, no transportation cost data were available.

Prices

Prices in this chapter are f.o.b. plant, usually at the first point of sale or captive use. This value does not include transportation from the plant or yard to the consumer. It does, however, include all costs of mining, processing, in-plant transportation, overhead costs and profit.

Compared with that of 1992, when the last full annual survey was conducted, the 1994 average unit prices increased nearly 5% to $4.19 per ton. By uses, the unit prices varied from a high of $8.02 for roofing granules to a low of $2.54 for fill. The largest increases in unit prices by uses were recorded for filtration sands, 18%; snow and ice control sand, 13.5%; railroad ballast, 13.4%; concrete products, 9.5%; and road base and coverings, 9.4%. Average unit prices declined for plaster and guinite sands, 9.4% and road stabilization-cement, 8.9%. *(See table 6.)*

Foreign Trade

The widespread distribution of domestic sand and gravel deposits and the high cost of transportation limits foreign trade, mostly to local transactions across international boundaries. U.S. imports and exports are small, representing only about 1% of the domestic consumption.

Exports of construction sand decreased 5.5% to 564,000 tons, compared with that of 1993, but the value increased 47.2% to $15.6 million. Canada was the major destination, receiving about 56% of the total, followed by Mexico with 26.2%. Exports of construction gravel declined 9.7% to 482,000 tons, while the value decreased 7.1% to $4.6 million. Canada was the major destination receiving about 87.8% of the total. *(See table 12.)*

Imports increased to 1.5 million tons, but the value decreased almost 4% to $14.8 million. Canada was the major source of imported construction sand and gravel with 74.7% of the total, followed by The Bahamas with 16.2%. *(See table 13.)*

Outlook

The demand for construction sand and gravel in 1995 is expected to be about 900 million tons, practically unchanged compared with that of 1994. It is estimated that the demand for construction sand and gravel will reach 915 million tons in 1996. The projected increases will be influenced by construction activity primarily in the public construction sector.

Construction sand and gravel f.o.b. prices are expected to increase only marginally, due to a slowdown in demand growth compared with the last several years. However, the delivered prices of construction sand and gravel are expected to increase, especially in and near metropolitan areas, mainly because more aggregates are transported from distant sources.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

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Other Sources

Aggregates Handbook, National Stone Association, 1991.

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Handbook of Concrete Aggregates, A Petrographic and Technological Evaluation, Dolar-Mantuani, L. Noyes Publications, 1983.

Industrial Minerals and Rocks, Fifth Edition, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc. 1983.

Canadian Aggregates Magazine.

Industrial Minerals Magazine.

Pit & Quarry Magazine.

Quarry Management Magazine.

Rock Products Magazine.

Stone Review Magazine.

TABLE 1
SALIENT U.S. CONSTRUCTION SAND AND GRAVEL STATISTICS 1/

		1990	1991	1992	1993	1994
Sold or used by producers:						
Quantity 2/	thousand metric tons	829,000	708,000 e/	834,000 3/	869,000 e/ 3/	891,000
Value 2/	thousand dollars	$3,270,000	$2,810,000 e/	$3,340,000 3/	$3,530,000 e/ 3/	$3,740,000
Exports	value, thousand dollars	$11,900	$19,000	$18,000	$15,600	$20,300
Imports	do.	$22,900	$16,600	$15,500	$15,400	$14,800

e/ Estimated.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Puerto Rico excluded from all sand and gravel statistics.

3/ Excludes Hawaii.

TABLE 2
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY GEOGRAPHIC REGION 1/

Geographic region	1993 e/ Quantity (thousand metric tons)	1993 e/ Percent of total	1993 e/ Value (thousands)	1993 e/ Percent of total	1994 Quantity (thousand metric tons)	1994 Percent of total	1994 Value (thousands)	1994 Percent of total
Northeast:								
New England	31,900 r/	3.6	$150,000	4.2	36,900	4.1	$174,000	4.6
Middle Atlantic	61,500	7.0	326,000	9.2	60,000	6.7	327,000	8.7
Midwest:								
East North Central	181,000	20.8	683,000	19.4	192,000	21.5	714,000	19.1
West North Central	92,400	10.6	288,000	8.2	95,200	10.7	306,000	8.2
South:								
South Atlantic	69,600	8.0	295,000	8.4	62,800	7.0	267,000	7.1
East South Central	39,800	4.5	160,000	4.5	42,800	4.8	171,000	4.6
West South Central	78,600	9.0	315,000	8.9	88,100	9.9	361,000	9.7
West:								
Mountain	150,000	17.2	562,000	15.9	143,000	16.1	586,000	15.7
Pacific	164,000	18.9	751,000	21.3	171,000	19.2	832,000	22.3
Total	869,000	100	3,530,000	100	891,000	100	3,740,000	100

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 3
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY QUARTER AND REGION 1/

(Thousand metric tons and thousand dollars)

Region	Quantity 1st Qtr.	Percent change 2/	Quantity 2nd Qtr.	Percent change 2/	Quantity 3rd Qtr.	Percent change 2/	Quantity 4th Qtr.	Percent change 2/	Total 3/	Value total
Northeast:										
New England	3,900	7.6	10,500	20.1	13,300	22.6	10,200	18.5	38,000	187,100
Middle Atlantic	7,200	1.0	20,500	6.9	24,100	6.0	20,400	22.1	72,140	393,300
Midwest:										
East North Central	17,400	0.1	53,200	10.6	60,900	1.0	49,300	-10.0	180,760	701,500
West North Central	12,300	30.9	29,700	16.3	38,000	19.3	26,900	-2.0	106,980	343,300
South:										
South Atlantic	13,500	0.1	19,000	1.1	19,900	6.4	17,500	-5.1	69,890	305,100
East South Central	7,600	12.4	12,300	9.9	13,100	13.9	10,600	3.9	43,640	181,000
West South Central	16,000	18.0	22,500	8.4	19,500	-29.7	16,200	-3.7	74,150	305,800
West:										
Mountain	31,000	24.0	44,400	16.8	49,400	16.5	36,700	-2.4	161,490	624,900
Pacific 4/	28,700	-2.0	40,700	-1.5	46,400	3.6	37,600	1.7	153,370	723,900
Total 3/	137,600	9.5	253,000	9.1	284,600	5.1	225,300	-0.9	913,900 5/	3,789,900 5/

1/ As published in the "Crushed Stone and Sand and Gravel in the Fourth Quarter of 1994" Mineral Industry Survey.

2/ All percentage changes are calculated using unrounded totals.

3/ Data may not add to totals shown because of independent rounding, and differences between projected totals by States and regions.

4/ Does not include Alaska and Hawaii.

5/ Includes Alaska.

TABLE 4
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

State	1993 e/			1994		
	Quantity (thousand metric tons)	Value (thousand dollars)	Unit value	Quantity (thousand metric tons)	Value (thousand dollars)	Unit value
Alabama	10,300	39,100	$3.80	12,500	47,600	$3.80
Alaska	13,100	42,600	3.25	15,700	56,200	3.58
Arizona	35,000	138,000	3.95	34,800	166,000	4.78
Arkansas	10,100	40,900	4.05	10,600	42,500	4.00
California	96,300	476,000	4.94	96,300	523,000	5.43
Colorado	29,000	118,000	4.05	29,000	109,000	3.76
Connecticut	6,400	34,900	5.45	5,420	28,000	5.17
Delaware	2,500	10,300	4.12	2,580	8,680	3.36
Florida	22,800	73,100	3.21	16,600	60,700	3.66
Georgia	4,600	16,600	3.61	5,520	19,800	3.59
Hawaii	--	--	--	521	4,740	9.10
Idaho	13,600	44,900	3.30	14,500	46,300	3.19
Illinois	34,500	137,000	3.98	37,900	150,000	3.96
Indiana	27,000	103,000	3.80	28,100	108,000	3.84
Iowa	16,600	64,700	3.90	15,300	58,200	3.80
Kansas	11,900	30,700	2.58	11,200	29,600	2.64
Kentucky	7,700	29,900	3.88	9,140	32,200	3.52
Louisiana	11,900	51,500	4.33	12,300	49,600	4.03
Maine	4,400	18,900	4.30	5,890	24,400	4.14
Maryland	11,200	72,200	6.45	8,920	61,200	6.86
Massachusetts	10,800	51,300	4.75	12,300	60,000	4.88
Michigan	45,000	158,000	3.50	48,800	160,000	3.28
Minnesota	30,500	85,400	2.80	29,500	90,000	3.05
Mississippi	14,500	57,300	3.95	12,400	53,200	4.29
Missouri	6,400	19,800	3.09	9,760	36,500	3.74
Montana	10,000	32,000	3.20	7,360	28,800	3.91
Nebraska	12,900	41,900	3.25	15,000	49,200	3.28
Nevada	24,900	108,000	4.32	22,700	106,000	4.67
New Hampshire	4,800	20,700	4.31	7,120	32,600	4.58
New Jersey	14,700	80,100	5.45	16,100	100,000	6.21
New Mexico	11,100	51,100	4.60	10,400	47,400	4.56
New York	34,900	162,000	4.63	28,000	138,000	4.93
North Carolina	11,100	53,800	4.85	11,100	50,700	4.57
North Dakota	7,700	20,400	2.65	6,810	18,500	2.72
Ohio	46,400	203,000	4.37	47,700	205,000	4.30
Oklahoma	9,700	27,300	2.81	8,480	27,200	3.21
Oregon	15,800	74,800	4.73	18,400	83,600	4.54
Pennsylvania	16,100	83,900	5.21	15,900	89,700	5.64
Rhode Island	2,500	13,900	5.56	2,310	14,200	6.14
South Carolina	6,800	21,800	3.21	8,600	26,100	3.03
South Dakota	8,300	25,000	3.01	7,700	23,700	3.08
Tennessee	7,200	34,000	4.72	8,710	38,000	4.36
Texas	47,100	195,000	4.14	56,700	242,000	4.27
Utah	16,000	56,000	3.50	21,100	69,600	3.30
Vermont	3,000	10,400	3.47	3,890	14,500	3.73
Virginia	9,000	40,500	4.50	8,060	33,400	4.14
Washington	40,200	158,000	3.93	39,600	165,000	4.17
West Virginia	1,400	6,700	4.79	1,380	5,970	4.33
Wisconsin	27,600	82,800	3.00	29,200	91,500	3.13
Wyoming	3,400	15,000	4.41	3,210	13,100	4.08
Total	869,000	3,530,000	4.06	891,000	3,740,000	4.20

e/ Estimated.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 5
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY QUARTER AND STATE 1/

(Thousand metric tons and thousand dollars)

State	Quantity 1st Qtr.	Percent change 2/	Quantity 2nd Qtr.	Percent change 2/	Quantity 3rd Qtr.	Percent change 2/	Quantity 4th Qtr.	Percent change 2/	Total 3/	Value total
Alabama	2,300	5.6	2,800	-6.6	3,000	12.2	2,500	3.6	10,600	41,300
Alaska 4/	--	--	--	--	--	--	--	--	13,500	45,200
Arizona	8,700	37.3	13,600	56.2	13,900	32.8	10,600	11.5	46,800	191,900
Arkansas	2,200	17.0	3,100	20.7	2,900	-2.6	2,500	-7.0	10,700	44,400
California	17,800	-4.8	24,100	-7.7	28,100	1.2	24,500	3.4	94,500	472,500
Colorado	4,600	7.6	7,800	-10.5	9,100	-1.4	6,200	-10.1	27,700	116,300
Connecticut	600	-1.3	1,700	4.7	2,400	11.6	1,900	-9.5	6,600	36,600
Delaware	100	-50.1	500	-47.0	800	20.9	500	-11.7	1,900	7,900
Florida	5,700	16.2	6,200	11.9	5,900	6.9	5,500	-20.2	23,300	78,100
Georgia	1,000	8.0	1,300	0.3	1,200	-8.5	1,100	-5.4	4,600	17,100
Hawaii 4/	--	--	--	--	--	--	--	--	--	--
Idaho	2,700	149.6	4,900	41.3	5,900	-0.3	4,100	31.0	17,600	59,800
Illinois	3,100	11.6	10,300	5.6	10,900	-7.7	8,500	-15.8	32,800	136,100
Indiana	3,700	11.8	8,800	16.4	8,900	-4.2	7,900	14.4	29,300	114,300
Iowa	1,800	40.7	5,600	22.0	6,300	7.0	4,500	-7.2	18,200	72,800
Kansas	2,300	51.5	3,900	12.3	4,200	12.1	3,100	-1.3	13,500	37,100
Kentucky	1,100	6.9	2,500	10.6	2,900	24.2	2,300	13.3	8,800	35,200
Louisiana	2,800	18.4	3,400	3.7	3,300	2.1	3,200	4.4	12,700	56,400
Maine	400	70.6	1,500	22.0	2,400	70.4	1,600	6.6	5,900	26,300
Maryland	1,700	-12.7	2,700	-8.2	3,200	1.5	2,900	-9.5	10,500	68,300
Massachusetts	1,900	10.9	3,400	19.0	3,500	-2.3	3,000	13.5	11,800	57,200
Michigan	3,100	-7.6	12,600	18.9	16,000	11.7	12,300	-26.4	44,000	160,600
Minnesota	2,900	-20.5	7,100	1.9	12,900	14.0	8,600	1.2	31,500	91,400
Mississippi	3,200	22.4	4,500	20.6	4,400	5.2	3,700	-8.5	15,800	64,800
Missouri	1,400	107.0	2,800	45.9	3,000	100.1	2,200	-5.3	9,400	30,500
Montana 5/	--	--	--	--	--	--	--	--	6,900	22,100
Nebraska	1,100	43.5	3,800	-9.5	4,200	-6.6	2,500	-28.5	11,600	38,300
Nevada	6,600	12.2	5,900	-5.2	6,800	11.8	5,100	-23.2	24,400	107,400
New Hampshire	500	-12.1	2,300	48.8	2,800	66.3	1,600	53.7	7,200	31,700
New Jersey	2,100	-5.5	4,400	7.5	4,700	6.4	4,200	9.3	15,400	85,500
New Mexico	2,500	33.5	2,900	-3.0	3,000	-7.3	3,000	-2.4	11,400	53,600
New York	4,800	35.2	11,500	17.9	14,200	12.6	11,900	33.2	42,400	203,500
North Carolina	2,100	-15.2	3,000	-9.6	3,500	26.9	2,800	14.4	11,400	56,400
North Dakota 5/	--	--	--	--	--	--	--	--	8,000	22,000
Ohio	5,100	-1.1	13,100	1.7	16,200	1.8	12,700	2.0	47,100	209,600
Oklahoma	2,300	31.1	2,800	8.0	3,100	3.2	2,400	2.2	10,600	31,300
Oregon	2,600	11.1	3,700	0.8	8,500	28.6	3,400	7.4	18,200	87,400
Pennsylvania	1,100	-18.8	5,000	0.1	5,900	1.5	4,900	22.4	16,900	89,100
Rhode Island 5/	--	--	--	--	--	--	--	--	2,800	15,800
South Carolina	1,600	23.3	2,100	25.2	1,900	3.2	1,800	-8.3	7,400	24,400
South Dakota	700	97.5	3,300	49.6	3,800	12.7	3,400	40.1	11,200	35,300
Tennessee	1,300	16.0	2,500	20.4	2,500	9.8	2,000	14.5	8,300	39,800
Texas	8,600	16.1	13,100	6.4	10,100	-46.6	7,900	-7.1	39,700	166,700
Utah 5/	--	--	--	--	--	--	--	--	21,700	79,200
Vermont	200	-8.3	700	-9.4	900	-23.5	1,300	70.3	3,100	10,900
Virginia	1,500	-16.0	2,600	1.5	2,800	7.3	2,300	17.0	9,200	42,300
Washington	8,400	4.3	13,300	17.5	11,300	1.6	9,200	-5.0	42,200	168,800
West Virginia	100	-35.6	400	-5.4	500	-2.3	400	41.6	1,400	6,700
Wisconsin	2,200	-20.8	8,300	12.1	9,100	0.4	7,800	-7.2	27,400	84,900
Wyoming	900	56.7	900	-15.0	900	-17.5	700	-4.2	3,400	15,100
Total	XX	XX	XX	XX	XX	XX	XX	XX	913,900	3,789,900

XX Not applicable.

1/ As published in the "Crushed Stone and Sand and Gravel in the Fourth Quarter of 1994" Mineral Industry Survey.

2/ All percentages changes are calculated using unrounded totals.

3/ Data may not add to totals shown because of independent rounding, and differences between projected totals by States and by regions.

4/ State not included in quarterly review.

5/ Due to a low number of reporting companies, no production estimates by quarters were generated.

TABLE 6
CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES IN 1994, BY MAJOR USE 1/

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Concrete aggregates (including concrete sand)	242,000	$1,130,000	$4.67
Plaster and gunite sands	7,460	39,700	5.32
Concrete products (blocks, bricks, pipe, decorative, etc.)	12,300	61,000	4.96
Asphaltic concrete aggregates and other bituminous mixtures	80,700	398,000	4.93
Road base and coverings	133,000	497,000	3.74
Road stabilization (cement)	2,050	7,150	3.49
Road stabilization (lime)	1,730	7,130	4.12
Fill	75,600	192,000	2.54
Snow and ice control	7,080	29,600	4.18
Railroad ballast	1,010	6,220	6.16
Roofing granules	182	1,460	8.02
Filtration	1,970	12,400	6.29
Other miscellaneous uses	9,290	42,300	4.55
Unspecified: 2/			
Actual	166,000	699,000	4.21
Estimated	150,000	611,000	4.07
Total	891,000	3,740,000	4.19

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 7
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY GEOGRAPHIC REGION AND MAJOR USE 1/

(Thousand metric tons and thousand dollars)

Geographic region	Concrete aggregates (including concrete sand)		Plaster and gunite sands		Concrete products (blocks, bricks, pipe decorative, etc.)		Asphaltic concrete aggregates and other bituminous mixtures		Road base and coverings 2/	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Northeast:										
New England	5,330	29,700	125	880	148	988	3,290	18,200	5,140	22,000
Middle Atlantic	18,700	111,000	741	4,740	953	7,130	7,140	40,700	8,140	35,700
Midwest:										
East North Central	38,900	149,000	650	3,030	3,350	14,800	17,000	63,500	25,200	91,000
West North Central	24,000	89,500	702	2,930	1,910	7,230	9,590	34,300	24,200	64,200
South:										
South Atlantic	27,300	123,000	1,250	5,590	2,460	9,160	3,280	14,400	3,590	18,000
East South Central	14,600	59,300	239	1,130	578	2,600	5,140	23,900	3,440	12,100
West South Central	36,400	164,000	536	2,510	479	1,650	4,230	21,400	5,030	19,300
West:										
Mountain	32,400	161,000	963	4,820	928	4,830	15,100	82,300	35,000	121,000
Pacific	44,700	246,000	2,250	14,000	1,470	12,700	15,800	99,700	27,300	128,000
Total	242,000	1,130,000	7,460	39,700	12,300	61,000	80,700	398,000	137,000	511,000

Geographic region	Fill		Snow and ice control		Railroad ballast		Other uses		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Northeast:										
New England	4,910	14,300	1,850	7,190	50	383	16,100	80,000	36,900	174,000
Middle Atlantic	3,460	10,500	2,080	10,400	32	181	18,700	107,000	60,000	327,000
Midwest:										
East North Central	18,400	51,800	1,120	3,940	62	401	86,800	336,000	192,000	714,000
West North Central	7,460	17,300	873	3,050	81	614	26,500	86,600	95,200	306,000
South:										
South Atlantic	6,970	13,800	220	931	289	1,340	17,400	80,300	62,800	267,000
East South Central	1,950	4,510	16	90	1	3	16,800	67,300	42,800	171,000
West South Central	10,100	18,100	16	46	7	35	31,300	134,000	88,100	361,000
West:										
Mountain	9,120	21,200	517	2,050	146	1,200	48,900	187,000	143,000	586,000
Pacific	13,200	40,900	386	1,890	347	2,070	65,000	287,000	171,000	832,000
Total	75,600	192,000	7,080	29,600	1,010	6,220	327,000	1,370,000	891,000	3,740,000

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes road and other stabilization (cement and lime).

TABLE 8
CONSTRUCTION SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 1994, BY REGION AND SIZE OF OPERATION 1/

Size range (metric tons)	Northeast				Midwest				South			
	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total
Less than 25,000	433	40.1	3,420	3.5	603	27.5	5,990	2.1	260	23.1	2,250	1.2
25,000 to 49,999	146	13.5	4,830	5.0	362	16.5	11,800	4.1	149	13.2	4,990	2.6
50,000 to 99,999	187	17.3	12,100	12.5	407	18.6	26,400	9.2	213	18.9	13,800	7.1
100,000 to 199,999	154	14.3	19,600	20.2	347	15.9	44,600	15.5	170	15.1	22,600	11.7
200,000 to 299,999	73	6.8	15,800	16.4	184	8.4	41,000	14.3	106	9.4	23,500	12.2
300,000 to 399,999	41	3.8	12,700	13.1	88	4.0	27,300	9.5	67	6.0	20,500	10.6
400,000 to 499,999	18	1.7	7,220	7.4	58	2.6	23,500	8.2	36	3.2	14,600	7.6
500,000 to 599,999	8	0.7	4,050	4.2	45	2.1	22,000	7.7	36	3.2	17,900	9.3
600,000 to 699,999	6	0.6	3,600	3.7	34	1.6	19,900	6.9	30	2.7	17,400	9.0
700,000 to 799,999	4	0.4	2,790	2.9	18	0.8	12,200	4.3	16	1.4	10,900	5.6
800,000 to 899,999	3	0.3	2,310	2.4	10	0.5	7,720	2.7	14	1.2	10,900	5.6
900,000 to 999,999	2	0.2	W	1.8	4	0.2	W	1.2	7	0.6	5,980	3.1
1,000,000 to 1,499,999	4	0.4	4,130	4.3	12	0.5	12,500	4.4	17	1.5	18,600	9.6
1,500,000 to 1,999,999	--	--	--	--	16	0.7	25,700	9.0	3	0.3	4,640	2.4
2,000,000 to 2,499,999	--	--	--	--	--	--	--	--	1	0.1	W	1.1
2,500,000 to 4,999,999	1	0.1	W	2.7	1	--	W	1.0	1	0.1	W	1.5
5,000,000 and over	--	--	--	--	--	--	--	--	--	--	--	--
Total	1,080	100	96,900	100	2,190	100	287,000	100	1,130	100	194,000	100

Size range (metric tons)	West				U.S. Total			
	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total
Less than 25,000	424	26.1	3,800	1.2	1,720	28.6	15,400	1.7
25,000 to 49,999	238	14.6	7,820	2.5	895	14.9	29,500	3.3
50,000 to 99,999	276	17.0	18,000	5.7	1,080	18.0	70,300	7.9
100,000 to 199,999	237	14.6	31,500	10.0	908	15.1	118,000	13.3
200,000 to 299,999	134	8.2	29,700	9.5	497	8.3	110,000	12.4
300,000 to 399,999	77	4.7	24,500	7.8	273	4.5	85,000	9.5
400,000 to 499,999	57	3.5	22,600	7.2	169	2.8	68,000	7.6
500,000 to 599,999	34	2.1	17,100	5.4	123	2.0	61,000	6.9
600,000 to 699,999	23	1.4	13,400	4.3	93	1.5	54,300	6.1
700,000 to 799,999	33	2.0	22,600	7.2	71	1.2	48,500	5.4
800,000 to 899,999	19	1.2	14,500	4.6	46	0.8	35,400	4.0
900,000 to 999,999	14	0.9	11,800	3.8	27	0.4	22,900	2.6
1,000,000 to 1,499,999	36	2.2	38,200	12.2	69	1.1	73,400	8.2
1,500,000 to 1,999,999	11	0.7	17,000	5.4	30	0.5	47,300	5.3
2,000,000 to 2,499,999	3	0.2	W	1.9	4	0.1	7,970	0.9
2,500,000 to 4,999,999	8	0.5	W	7.6	11	0.2	32,200	3.6
5,000,000 and over	1	0.1	11,200	3.6	1	--	11,200	1.3
Total	1,630	100	314,000	100	6,020	100	891,000	100

W Withheld to avoid disclosing company proprietary data; included with "Total."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 9
NUMBER OF CONSTRUCTION SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 1994, BY GEOGRAPHIC REGION 1/

Geographic region	Mining operations on land				Dredging operations	Total active operations
	Stationary	Portable	Stationary and portable	No plants or unspecified		
Northeast:						
New England	169	162	41	54	2	432
Middle Atlantic	200	292	56	62	42	653
Midwest:						
East North Central	398	385	101	132	87	1,100
West North Central	238	433	54	94	267	1,090
South:						
South Atlantic	119	48	13	91	139	410
East South Central	120	24	7	18	65	234
West South Central	217	70	15	79	101	482
West:						
Mountain	290	513	107	54	17	981
Pacific 2/	311	192	71	41	29	644
Total	2,060	2,120	465	625	749	6,020

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.

TABLE 10
NUMBER OF CONSTRUCTION SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 1994, BY STATE 1/

State	Mining operations on land				Dredging operations	Total active operations
	Stationary	Portable	Stationary and portable	No plants or unspecified		
Alabama	38	7	2	8	21	76
Alaska 2/	5	8	--	3	1	17
Arizona	58	55	20	2	2	137
Arkansas	43	11	3	7	7	71
California	171	69	39	12	16	307
Colorado	55	112	35	10	11	223
Connecticut	24	19	8	3	1	55
Delaware	3	--	--	2	3	8
Florida	9	1	2	10	38	60
Georgia	10	--	--	2	31	43
Hawaii	2	3	--	2	--	7
Idaho	38	84	2	14	1	139
Illinois	53	31	23	13	31	151
Indiana	61	31	17	11	21	141
Iowa	48	51	3	14	40	156
Kansas	17	27	7	25	49	125
Kentucky	12	2	3	1	7	25
Louisiana	23	4	--	7	43	77
Maine	28	53	6	22	--	109
Maryland	23	6	4	18	3	54
Massachusetts	60	18	8	7	1	94
Michigan	93	144	19	52	12	320
Minnesota	75	164	23	23	3	288
Mississippi	42	3	1	8	26	80
Missouri	40	14	1	2	37	94
Montana	37	51	7	7	--	102
Nebraska	24	22	4	3	138	191
Nevada	19	44	11	9	1	84
New Hampshire	23	22	6	4	--	55
New Jersey	28	5	8	3	16	60
New Mexico	36	61	9	2	1	109
New York	116	253	34	52	11	466
North Carolina	26	21	1	34	31	113
North Dakota	12	59	8	1	--	80
Ohio	109	33	21	39	21	223
Oklahoma	20	13	3	16	30	82
Oregon	44	27	10	5	7	93
Pennsylvania	56	34	14	7	15	126
Rhode Island	9	--	5	--	--	14
South Carolina	19	8	2	13	17	59
South Dakota	22	96	8	26	--	152
Tennessee	28	12	1	1	11	53
Texas	131	42	9	49	21	252
Utah	33	73	17	8	--	131
Vermont	25	50	8	18	--	101
Virginia	23	12	4	12	15	66
Washington	89	85	22	19	5	220
West Virginia	6	--	--	--	1	7
Wisconsin	82	146	21	17	2	268
Wyoming	14	33	6	2	1	56
Total	2,060	2,120	465	625	749	6,020

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.

TABLE 11
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY REGION AND METHOD OF TRANSPORTATION 1/

(Thousand metric tons)

Geographic region	Truck	Rail	Water	Other	Not transported	Not specified	Total
Northeast:							
New England	18,300	263	--	--	4,500	13,800	36,900
Middle Atlantic	31,600	4	1,570	64	7,620	19,100	60,000
Midwest:							
East North Central	80,600	158	4,610	1,100	16,000	89,200	192,000
West North Central	47,800	442	4,210	144	9,950	32,700	95,200
South:							
South Atlantic	37,000	1,470	1,760	2	4,830	17,700	62,800
East South Central	18,900	580	1,470	47	3,180	18,600	42,800
West South Central	40,500	2,930	99	--	15,300	29,200	88,100
West:							
Mountain	74,400	32	--	789	15,300	52,500	143,000
Pacific	69,100	1,120	4,260	428	26,400	69,100	171,000
Total	418,000	6,990	18,000	2,570	103,000	342,000	891,000

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 12
U.S. EXPORTS OF CONSTRUCTION SAND AND GRAVEL IN 1994, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country or Territory	Sand		Gravel	
	Quantity	F.a.s. value 2/	Quantity	F.a.s. value 2/
North America:				
Aruba	2	35	(3/)	10
Bahamas, The	1	79	14	27
British Virgin Islands	--	--	3	36
Canada	316	3,030	423	2,180
Costa Rica	1	379	(3/)	15
Dominican Republic	--	--	2	32
El Salvador	4	98	--	--
Guadeloupe	--	--	11	132
Jamaica	1	55	--	--
Martinique	--	--	1	13
Mexico	148	4,060	13	1,540
Turks And Caicos Island	1	4	3	46
Other 4/	(3/)	111	(3/)	17
Total	475	7,860	473	4,080
South America:				
Argentina	9	1,460	(3/)	29
Ecuador	3	176	--	--
Peru	2	243	--	--
Venezuela	8	1,470	1	98
Other 5/	1	83	--	--
Total	23	3,430	1	127
Europe:				
Belgium	1	134	1	37
Czech Republic	5	98	--	--
Germany	29	841	2	81
Spain	1	42	--	--
Sweden	(3/)	87	1	20
United Kingdom	2	1,080	(3/)	8
Uzbekistan	1	3	--	--
Other 6/	1	364	(3/)	6
Total	42	2,650	2	152
Asia:				
Hong Kong	7	160	(3/)	14
Japan	10	609	1	88
Philippines	2	44	--	--
Singapore	3	145	--	--
Taiwan	1	58	2	108
Other 7/	(3/)	260	1	65
Total	23	1,280	5	276
Oceania:				
Other 8/	(3/)	196	(3/)	14
Total	(3/)	196	(3/)	14
Middle East:				
Other 9/	(3/)	62	--	--
Total	(3/)	62	--	--
Africa:				
Other 10/	(3/)	136	--	--
Total	(3/)	136	--	--
Grand total	564	15,600	482	4,640

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.

3/ Less than 1/2 unit.

4/ Includes Belize, Bermuda, Cayman Islands, Guatemala, Haiti, the Netherlands Antilles, St. Lucia, and Trinidad and Tobago.

5/ Includes Brazil, Chile, Colombia, and Suriname.

6/ Includes Bulgaria, France, Hungary, Ireland, Italy, Latvia, the Netherlands, Norway, Russia, and Switzerland.

7/ Includes China, India, Indonesia, the Republic of Korea, Malaysia, Pakistan, and Thailand.

8/ Includes Australia, France, and Marshall Islands.

9/ Includes Kuwait, Saudi Arabia and the United Arab Emirates.

10/ Includes Algeria, Angola, Congo, Egypt, Nigeria, and Zaire.

Source: Bureau of the Census.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF CONSTRUCTION SAND AND GRAVEL, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country or Territory	1993		1994	
	Quantity	C.i.f. value 2/	Quantity	C.i.f. value 2/
Antigua and Barbuda	39	455	--	--
Australia	12	852	7	784
Bahamas, The	197	549	243	617
Barbados	8	72	--	--
British Virgin Islands	2	55	4	71
Canada	962	7,610	1,120	7,120
Dominica	9	71	14	162
Dominican Republic	2	49	--	--
France	1	206	1	222
Germany	3	2,140	55	2,880
Guyana	3	18	4	50
Japan	38	888	2	498
Macao	--	--	1	9
Malaysia	22	786	5	94
Martinique	--	--	16	154
Mexico	8	592	27	864
Netherlands Antilles	5	58	2	32
Norway	4	201	4	163
St. Lucia	--	--	1	5
Sweden	1	147	(3/)	94
United Kingdom	1	546	1	496
Other 4/		147	1	471
Total	1,320	15,400	1,500	14,800

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.

3/ Less than 1/2 unit.

4/ Includes Belgium, Chad, China, Denmark, Hong Kong, Iceland, India, Indonesia, Italy, Papua New Guinea, Peru, Philippines, Poland, Solomon Islands, and Taiwan.

Source: Bureau of the Census.

INDUSTRIAL SAND AND GRAVEL

By Wallace P. Bolen

Industrial sand and gravel production, consumption, and exports increased in 1994 compared with 1993. However, imports of 22,000 metric tons represented only one-half of the level from the previous year. Several small mines ceased operation during 1994 and some consolidation continued among the larger producers. Industrial sand and gravel, often termed "silica," "silica sand," and "quartz sand," includes high SiO_2 content sands and gravels. These sands are used in glassmaking, for foundry, abrasive, and hydraulic fracturing applications, and many other uses. The specifications for each use varies but silica resources for most markets are abundant. Leading producing States were Illinois, New Jersey, Michigan, Texas, and California. In almost all cases, silica mining employs open pit mining methods with standard mining equipment. Sand and gravel mining, in the vast majority of cases, has little environmental impact except for temporarily disturbing the immediate environment while mining operations are active.

Production of industrial sand and gravel in 1994 increased to 27.3 million metric tons, about 4% more than 1993's production. Production increased in response to greater demand for many uses including foundry sand, flat and fiber glass sand, and for silica used in ceramics production and in the "whole grain filler/building products" category.

Exports of silica sand and gravel increased over 7% in quantity and 12% in value compared with that of 1993. Imports of industrial sand and gravel continued to decline, 50% in quantity and 27% in value compared with the previous year. Domestic apparent consumption of industrial sand and gravel in 1994 was 25.4 million tons, an increase of about 4% compared with that of 1993. (See table 1.)

Legislation and Government Programs

Health and safety regulations continued to be the predominate concern in the relationship between governments and the industrial sand and gravel industry. Trade rulings and foreign agreements also impacted this industry but to a much smaller degree.

The issues surrounding silica dust, silicosis, and cancer have been highlighted in this report in previous years. Beyond this continuing concern, another health concern involved the debate on whether ceramic fibers, including glass fibers, are carcinogens. Several reports in 1994 discussed the listing by the Department of Health and Human Services that these fibers are possible carcinogens and reviewed the ramifications for the Occupational Safety and Health Administration and other regulatory agencies. The findings on glass wool, or fiberglass, were disputed by the North American Insulation Manufacturers Association because of the methodology used in the study.[1]

Concerning the relationship between silica and lung cancer, California's Office of Environmental Health Hazard Assessment held a meeting to review health affects. Reports from the conference revealed that three prestigious researchers expressed consistent views that the relationship of silica and lung cancer is neither substantiated nor understood. Concerned Californians and others involved at the meeting have formed a coalition to educate the Government and the public and to present deficiencies in proposals to regulate crystalline silica.[2]

The American Mining Conference (AMC) also was involved in the issue through direct comments to the National Institute for Occupational Safety and Health and through legal challenges to recent air quality rulings. Additionally, AMC helped sponsor an International Conference on Crystalline Silica Health Effects in Baltimore in April 1994. With the National Industrial Sand Association, AMC has undertaken a major epidemiological study of lung cancer mortality in a mining population.[3] In a related development that will impact silica miners, the November 15, 1994, Federal Register published a proposed tougher standard on the training and use of respirators.

On the trade front, the International Trade Commission determined in June that no U.S. industry was either materially injured of threatened financially by imports of silicon carbide from China.[4] However, the number of North American silicon carbide producers has shrunk rapidly since the Chinese began to target exports of silicon carbide to North America.

Glass trade between Japan and the United States also has been a contentious issue. According to a Glass Industry magazine report, Japan's $4.5 billion flat glass market will become more accessible because of a recent agreement. Wholesalers in Japan will agree to obtain 30% to 40% of their flat glass from nontraditional sources.[5]

Production

Domestic production data for industrial sand and gravel were developed by the U.S. Bureau of Mines (USBM) from one voluntary survey of U.S. producers. Of the 163 industrial sand and gravel operations surveyed, 149 (91%) reported to the USBM. Their combined production represented about 96% of the U.S. total published in table 1. The production of nonrespondents was estimated mostly using employment data. Of the 163 operations, 152 (93%) were active and 11 idle.

The Midwest (East and West North Central regions) continued to lead the Nation in production with about 45% of the 27.3 million metric tons produced in the United States, followed by the South (South Atlantic, East and West South Central regions) with about 34% and the West (Pacific and Mountain regions) with 12%. *(See table 2 and figure 1.)*

The seven leading States in the production of industrial sand and gravel, in descending order of volume, were Illinois, Michigan, California, New Jersey, Wisconsin, Texas, and North Carolina. Their combined production represented 55% of the national total. Among these seven States, New Jersey experienced an 8% decrease in production while California had a 3% decrease compared with 1993. Michigan's production increased 12%, Wisconsin and Texas both had 10% increases, and North Carolina's production increased 9%. Illinois, the long-time leader among the States, had a healthy 5% increase in production. *(See tables 3.)*

The USBM canvassed 82 producers of industrial sand and gravel with 152 active operations. About 76% of the industrial sand and gravel was produced by 47 operations, each with an annual production of more than 200,000 tons. The 10 leading producers of industrial sand and gravel were, in descending order of tonnage, Unimin Corp., U.S. Silica Co., Fairmount Minerals Ltd., The Morie Co. Inc., Oglebay Norton Co., Badger Mining Corp., Construction Aggregates Corp., Nugent Sand Co. Inc., Simplot Industries Inc., and Sargent Sand Co. Their combined production, from 62 operations, represented 72% of the U.S. total. (See tables 4 and 5.)

After a very quiet 1993, merger and acquisition activity heated up again in 1994 and is expected to continue in 1995. Oglebay Norton Industrial Sands, Inc., the industrial sand and gravel operations of Oglebay Norton Co., Cleveland, OH, purchased Vulcan Materials Co.'s, Voca, TX, sand plant and now controls two substantial hydraulic fracturing sand (frac sand) producers. Oglebay Norton also instituted historical changes in 1994 by removing the long held names of several of its subsidiaries in order to unify all its operations under the Oglebay Norton Industrial Sands name. This included the dropping of the following well known names: California Silica Products Co., San Juan Capistrano, CA; Central Silica Co., Howard and Glenford, OH plants; and Texas Mining Co., Brady, TX. Oglebay Norton should now maintain itself as one of the top five producers in the United States.

In other developments, another Ohio-based company, Fairmount Minerals, Chardon, OH, on October 1, 1994, purchased Schrader Sand and Gravel Co.'s 60,000 to 80,000 tons per year operation in Beaver, OH. Fairmount now operates five plants in three States and has a secure position as the third largest producer in the United States. U.S. Silica finalized the closing of its Ledyard, CT, mine and mill, selling the site to Mashantucket Western, affiliated with the Pequot Tribe of Connecticut, a native American group. In North Carolina, KMG Minerals Inc., Kings Mountain, was purchased by Franklin Industries, Inc. KMG Minerals is a producer of silica and construction sands, mica, feldspar, and kaolin. Franklin Industries, Nashville, TN, is one of the nation's leading producers of chemical and filler grade calcium carbonate and will now become the largest muscovite mica producers in North America.

Recycling of silica sands was limited to some foundry sands, particularly those used for making cores and molds with no-bake resin-bonded sands, some abrasive and airblasting sands, and, increasingly, post consumer glass and scrap glass (cullet) that substitutes for batch mix (including industrial sand). Most glass recycling was restricted to container glass, with green and amber cullet consumed in greater amounts for glass production because it is more difficult to use cullet in flint batch mixes.

Glass recycling was put at 35% in the United States for 1993, the fifth straight year of growth. This included glass used in glasphalt and those that were refilled, and represents an increase from the 1992 rate of 33%. Some glass manufacturers reported a shortage of cullet while others experienced unacceptable cullet because of contamination and coloring mixing of the cullet.[6] The price for cullet varied based on region and grade (flint (clear), brown (amber), or green) and location. Cullet from consumers generally passes through a processor, who receives it from municipalities, counties, etc., and the processor then provides it to the glassmaker. Prices for flint glass to the glassmaker generally varied from $24 to $65 per ton in early 1994. Brown glass ranged from $15 to $55 per ton and green glass from $0 to $65 per ton.

As the level of cullet used in glass production increases, so does the level of quality required. Contamination of cullet by ceramics and nonmagnetic materials was an increasing concern. Because of the increased use of recycled glasses, restrictions on the iron and chromium levels in glass sands have become stricter and the proportion of refractory particles allowed has been reduced to almost zero. The Fe_2O_3 content of a typical glass silica sand is now as low as 0.015 to 0.02% for flint glass manufacture and 0.1 to 0.15% for colored glass. Additionally, recycling of amber and green glass was substantially greater than flint glass; and therefore, lower grade deposits are in less demand.

In the glass fiber arena, a 1993 report discussed the growing use of recycled container glass in fiberglass production. Adding another twist, Wil-Mfg., Inc., Guelph , Canada, opened a facility for glass fiber recovery. The recovered glass, from fiber glass waste materials, will be called Eco-Glass and used to strengthen composites of plastic and rubber, and as components of construction and building materials.[7]

Another example of sand recycling, albeit employing some license with the term recycling, was reported by a cement producer in Canada. At the Lafarge Corp.'s St. Constant, Quebec, plant, used foundry sand has been incorporated into the material mix for cement manufacture. Using innovation and common sense, the employees at the plant have successfully used a variety of "recycled" materials to meet their raw material needs.[8]

On the negative side, recycling of silica refractories is hardly ever done. Because recycling these refractories requires crushing and grinding, silica dust is generated. The dust must be controlled according to hazardous material regulations and this makes it prohibitively expensive to recycle.

International trends toward increased recycling of glass and foundries sands and innovative ideas on recycling other materials should influence greater recycling of silica products.

Consumption

Sand and gravel production reported by producers to the USBM was actually material used by the companies or sold to their customers. Stockpiled material was not reported until consumed or sold. Of the 27.3 million metric tons of industrial sand and gravel sold or used, 39% was consumed as glassmaking sand and 24% as foundry sand. Other important uses were frac sand (6%) and abrasive sand (5%).

The production of industrial sand and gravel in the United States has developed in response to market location and vice-versa as industry sometimes located near silica resources. Because silica deposits (or resources) are found throughout the United States, locating a consuming industry specifically to be near a silica source was not always a priority, although certainly a consideration. The auto industry, responding to iron, coal, clay, and silica resources, centered in the Midwest and thus foundry sands were greatly exploited in Michigan, Ohio, Indiana, Illinois, and other regional States. This resulted in over 75% of the foundry sand being produced in the Midwestern region in 1994.

The glass industry, somewhat conversely, had to locate plants where they could minimize the shipping distance of finished glass products. Hence, glass plants were more evenly distributed as 41% of glass sand was produced in the Southern region, 32% in the Midwest, 15% in the West, and 12% in the Northeast, in 1994. To varying degrees, all silica production was similarly influenced as markets and consuming industries either forced the silica mining location or were forced to locate near the silica source.

The amount of sand sold for container glass remained near 1993 levels, while the total shipments of glass containers dropped 1.3% during the year. These factors reinforce the idea that available cullet was not meeting the potential market; and therefore, more virgin material was being used to offset the lack of cullet. It is instructive to notice that container shipment numbers are a limited gauge when discerning silica sand's consumption and future. The share of silica sold for all types of glassmaking as a percentage of all silica sold dropped to its lowest level since 1985 when glass markets consumed only 35% of silica sold.

In an indication of improved demand for flat glass, PPG Industries announced plans to resume float glass production of the second line at its Mount Zion, IL, plant in 1995. The line has been idle since 1991 and will allow the plant to produce for the auto and other markets beyond the construction market it currently served. Similarly, Guardian Industry announced plans to construct a float glass plant at DeWitt, IA. Its seventh float glass plant in the United States, the plant is expected to produce for applications including windows, doors, tabletops, mirrors, skylights, and commercial building curtain walls. AFG Industries, Inc., maneuvering to keep pace, announced that it would start manufacturing operations at its Cinnaminson, NJ, facility in April 1995. They also cited increased demand for flat glass experienced during 1994.

Besides flat glass, the fiberglass industry also showed signs of strengthening. Schuller International plans to invest $50 million in capacity additions to its Defiance and Waterville, OH plants. And, after sitting idle for 7 years, the Jackson, TN, plant of Owens-Corning Fiberglas Corp. was reopened.

The brightest market in 1994 was foundry, where sales were up 14% compared with 1993. Continued strong activity in the auto industry spurred greater foundry activity and silica consumption. Sales of light vehicles grew at an 8.5% rate in 1994, compared with 1993, and are expected to see continued growth in 1995.

The blasting market consumed less silica in 1994, as sales continued to fall, dropping 5% from 1993. The blasting market suffers, not from increased recycling, although there was some blast sand recycled, but from increased concern about health hazards related to respirable silica. Consumers are increasingly using competing materials such as garnet, slags, and glass beads. *(See table 6.)*

Silica was generally used in plastics as a filler, extender, and reinforcer. More specifically, it was used to thicken liquid systems, as a thixotropic agent, flatting agent, and was used to avoid plateout in PVC (polyvinyl chloride). As segregated for this survey, ground silica used as a filler was 68,000 tons, whole grain filler amounted to 1.25 million tons in 1994.

Specialty silicas were usually produced by means of chemical and thermal processing of natural silica or as a byproduct of other mineral or chemical processing. Although the USBM did not specifically collect information for specialty silicas, its consumption does affect natural silica sales. Specialty silicas and silanes, included, but were not limited to, fumed silica, fused silica and quartz, precipitated silica, silica gels, silicones, and ultra-high purity silica. These silicas were used in abrasives, catalysts, coatings, electronics, encapsulants, food, health care, optics, paper, plastics, refractories, rubber, specialty coatings, water treatment, and many others. On table 6, industrial sand and gravel that would find its way into these specialty silicas is most likely reported in the categories "chemical" and "silicon metal." Silica sales for chemical production increased nearly 14% in 1994, compared with 1993. Sodium silicate, a prime silica chemical, has had increases in production for the last 3 years and reached a 10-year high in 1993. Production of sodium silicate rose 8% between 1983-1993 and 3% from 1992-1993.

Many silicon-based ceramics also are considered a specialty or nontraditional use for silica and offer potential growth for silica. Superior Graphite Co. had its first full year of operation at its Hopkinsville, Ky, plant. The plant has the capacity to produce 120 metric tons per year of beta silicon carbide and can expand to 180 tons per year which it is likely to do so in the near future.[9]

Northeast.—Cumberland County, NJ, continued to be the largest source for the glass and foundry sand markets in the region. Unimin, U.S. Silica, and Morie, all of which operated plants in the county, were among the largest producers of sand for these markets. U.S. Silica's plant in Huntingdon County, PA, also produced significant amounts of sand for the glass market. Morie and Ricci Brothers Sand Co. Inc., both in Cumberland County, NJ, produced a major percentage of the abrasive blast sand in the region.

Midwest.—Unimin's plants in LaSalle and Ogle Counties, IL; LeSueur and Scott Counties, MN; and Columbia County, WI, were among the leaders in producing sand for all four major markets: the blast, foundry, frac, and glass sand markets. Fairmount Minerals, with operations in Berrien and Van Buren Counties, MI; Geauga County, OH; and La Salle County, IL; was also a major producer of sand for the four major markets in the region. U.S. Silica's plant in La Salle County, IL, was a large producer for the glass, foundry, and frac markets and its St. Louis County, MO, operation was a large producer for the glass market. Construction Aggregates Corp., Ottawa County, MI; Nugent Sand Co. Inc., Muskegon County, MI; and Sargent Sand Co., Wexford County, MI; were all large producers for the foundry industry. Badger Mining, Jackson and Green Lake Counties, WI, was a major producer for the blast, foundry, and frac markets. Manley Brother's of Indiana, LaSalle County, IL, was a large producer for the foundry and glass markets. Kaw Valley Sand and Gravel Co., Wyandotte County, KS, was a major producer of blast sand.

South.—Unimin and U.S. Silica Co. were two of the largest producers of sand for the glass and foundry markets. Unimin's major plants were in Izard County, AR; Richmond

County, NC; Pontotoc County, OK; and Frederick County, VA. U.S. Silica's Bullock County, AL; Johnston County, OK; Lexington County, SC; Limestone County, TX; and Morgan County, WV, operations were its major contributors for these markets. Morie's Tuscaloosa County, AL; Marion County, GA; and Carrol County, TN, plants were large producers of foundry and glass sand. Cobb Industrial Corp. Red River Parish, LA; Foster-Dixiana Corp., Lexington County, SC; Huey Stockstill Inc., Pearl River County, MS; Mid-State Sand and Gravel Co., Allen Parish, LA; Pioneer Concrete of Texas Inc., Liberty County, TX; and Specialty Sand Co., Newton County, TX, were large producers of blasting sand. JEBCO Abrasives Inc., Colorado County, TX, a company new to this year's report, was also a substantial blast sand producer. W. R. Bonsal and Co. and B. V. Hedrick Gravel and Sand Co., both in Anson County, NC, produced a large percentage of the industrial gravel used in the production of silicon and ferrosilicon. Oglebay Norton, with two operations in McCulloch County, TX, was the largest producer of frac sand, and an important contributor of blast sand for the region. WHIBCO in Kershaw County, SC, was an important producer of foundry sand. APAC Arkansas Inc., Crawford County, AR; Florida Rock Industries Inc., Putnam County, FL; and Short Mountain Silica Co., Hawkins County, TN, were important producers of glass sand.

West.—Corona Industrial Sand Co., Owens-Illinois, Simplot Industries, and Unimin were the four largest producers of glass sand in the region, with major operations in Riverside County, CA; Amador County, CA; Clark County, NV; and Contra Costa County, CA, respectively. Lane Mountain Silica, Stevens County, WA; Lone Star Industries Inc., Monterey County, CA; P.W. Gillibrand Co., Ventura County, CA; and Gordon Sand Co., Santa Barbara County, CA, were the major suppliers for the sand blasting industry in the region. Simplot Industries, Clark County, NV, also supplied a large portion of the foundry sand consumed. FMC Corp., Power County, ID; Rhone-Poulenc Basic Chemicals Co., Beaverhead County, ID; and Monsanto Industrial Chemicals Co., Caribou County, ID, each produced industrial gravel for use as a flux in elemental phosphorus production.

Transportation

Of the total industrial sand and gravel produced, 61% was transported by truck from the plant to the site of first sale or use, down from 63% in 1993; 36% was transported by rail, up from 34% in 1993; 2% by waterway; and 1% was not transported. Because most of the producers did not report shipping distances or cost per ton per mile, no transportation cost data were available.

Prices

Compared with that of 1993, the average value, f.o.b. plant, of U.S. industrial sand and gravel increased 3% to $17.86 per metric ton. Average unit values for industrial sand and industrial gravel were $18.14 and $11.88 per ton, respectively. Nationally, ground industrial sand used as fillers for rubber, paint, and putty, etc., had the highest value per ton ($151.97), followed by silica for swimming pool filters ($67.00), silica for well packing and cementing ($51.37), ground silica sand used in ceramics ($48.91), molding and core facings ($46.31), ground silica for scouring cleansers ($44.86), ground sand used for fiberglass ($35.01), frac sand ($31.54), and silica for whole grain fillers/building products ($29.24).

Industrial sand and gravel price changes were greatly mixed as some markets were level, others had small increases or decreases, and still others experienced large increases or decreases. This situation was possible because although the silica was essentially the same, most markets were very independent from each other and price competition was influenced by availability, regulations and health concerns, and competition from other materials. Those end uses that sustained greater prices in 1994, compared with 1993, included: blasting, chemicals, container and specialty glass, fiberglass, fillers, filtration, foundry, recreational, roofing granules and fillers, and traction. Silica for ceramics, flat glass, metallurgical, and well packing and cementing experienced a decrease in unit value.

The average value per ton of industrial sand and gravel was highest in the West ($19.89), followed by the South ($19.08), the Northeast ($18.57), and the Midwest ($16.22). Prices can vary greatly for similar grades of silica at different locations in the United States. For example, glass sand average value per ton varied markedly, from $20.02 in the West to $11.15 in the Midwest. Tighter supplies and higher production costs in the West and much greater competition in the Midwest caused the difference in the cost of sand and gravel in these two regions.

Foreign Trade

Exports of industrial sand, compared with those of 1993, increased 7% to 1,880,000 tons, while the value increased 12%. Export distribution is as follows: 79% went to Canada, 8% went to Mexico, and the remainder to numerous other countries throughout the world. Compared with those of 1993, imports for consumption of industrial sand dropped 50% to 22,000 tons valued at $1.8 million. Silica imports vary greatly from year to year but are always rather insignificant. Australia supplied 50% of the silica imports for 1993, averaging near $58.55 per ton (including insurance and freight cost to the U.S. port). The Australian imports were the relatively low priced silica while higher priced silica came from Germany, Italy, Japan, Sweden, the United Kingdom, and Venezuela. *(See tables 7 and 8.)*

World Review

World production of industrial sand and gravel, based on information usually provided by foreign Governments, was estimated to be 111 million metric tons, up nearly 5% from 1993. The United States was the leading producer followed by, in descending order, the Netherlands, Germany, Austria, and France. Most countries in the world had some production and consumption of industrial sand and gravel because it is essential to the glass and foundry industries. However, because of the great variation in descriptions and usage for silica sand and gravel, it was difficult to get reliable information. Beyond those countries listed, several other countries were believed to have had some type of silica production and consumption. *(See table 9.)*

The Financial Times of London reported a serious shortage of lead glass used in televisions and computers. The manufacturers of these lead glass cathode tubes are running at full capacity but will still come up 10 million tubes below the demand of 160 million in 1994. There are no U.S. manufacturers of these tubes. All production is done in France, Germany, Japan, and the Netherlands.[10]

Current Research and Technology

Research and development involving specialty silicas flourished in 1994 as reflected in the regular reporting on the topic. Silicones used in the electronics industry were praised for their quick curing times as they compete for the adhesives and sealants needs of the industry. With silicones currently holding only a 7% share of the $70 million market, projections are that silicones' share will rise.[11]

Another sign of growth in the specialty segment was Degussa Corp.'s announcement of a 30 to 50 million pound capacity increase for precipitated silica per year until 1997 in North America. The new capacity will allow for new high-performance product applications. Degussa has fumed silica plants in Waterford, NY, and Mobile, AL, and a precipitated silica plant in Chester, PA.[12]

Additionally, Cabot Corp., PPG Industries, and W. R. Grace, have all announced capacity increases for silica products. These capacities increases will mainly be outside of the United States but indicate growth potential for the specialty markets overall.[13] PPG announced it is planning to expand its precipitated amorphous silicas plant at Lake Charles, LA. The plant will produce several types of reinforcing silicas and a dentifrice silica.[14]

PQ Corp, Valley Forge, PA, the largest producer of sodium silicate, a traditional silicate, is also a major producer of zeolites, colloidal silicas and silica gels. PQ has seen great growth in all its segments and has rapidly opened new manufacturing facilities. They also opened a new plant in April 1994, at Raleigh, NC, to make hollow glass spheres. Its silica gel is used as catalyst and catalyst support for polyethylene production, and for brewing applications. They are also targeting zeolites and silicas for beer fining.[15]

In another promising announcement, Rhone-Poulenc is building a 20,000-ton-per-year precipitated silica plant at Chicago Heights, IL. The facility will produce material for the rubber, dentifrice, and specialty chemical markets. The plant will also produce special abrasive grades of silicas. Rhone-Poulenc is also developing the "green" tires concept through micropearl silicas for use in these fuel-saving tires.[16]

Also, OSi Specialties Inc. has more than doubled trisiloxane copolymers capacity at its Sisterville, WV, plant. The company said that the use of trisiloxane compositions is growing at a rapid rate. Uses for these products include household and institutional specialties, printing inks, adhesives and sealants, agriculture, and chemical processing markets.[17]

Finally, Wacker-Chemie is studying a project to produce silicone raw materials in the United States, possibly in Louisiana or Michigan. Annual U.S. silicone sales are more than $100 million and growing at 5% per year.[18]

In other silica related research and development, Dow Corning reports completing pilot-plant studies of a silicon production process that it says is environmentally cleaner, more energy efficient, and safer than current technologies. This plant study, in Selkirk, Manitoba, Canada, was mentioned in this publication in 1992. Dow Corning is currently looking for a silicon producing company partner(s) to commercialize the technology.[19]

Researchers at Lawerence Livermore National Laboratory are using buckyballs to manufacture silicon carbide microchips, electromechanical devices, and sensors. The technology is expected to be used for microelectromechanical devices, flameout detectors in aircraft engines and tiny engine parts built onto microchips.[20]

Scientists at General Electric report the first commercially feasible process for making high-temperature integrated circuits from silicon carbide (SiC). These devices will be able to withstand temperatures as high as 500° C.[21]

Glass Fiber Enterprises Ltd., partnered with a group from the former Soviet Union, announced a new product in the Siltex™ line of high-silica yarns and fabrics. The product has improved strength and abrasion resistance for aerospace applications.[22]

Owens-Corning has introduced Miraflex fiber, the first new form of glass fiber in nearly 60 years, according to the company. Miraflex is composed of two different forms of glass fused together in a single filament. According to the company, it is the first glass fiber that successfully holds up under typical textile processes. Unlike traditional, straight glass fibers, the product's fibers are randomly twisted, flexible, soft to the touch, and virtually itch-free.[23]

Research and development also continued in ceramics concerning SiC and silicon nitride (Si_3N_4). Advanced Refractory Technologies Inc. will participate in a metal composites demonstration program with Hughes Aircraft. The program will address the feasibility of SiC whisker-reinforced aluminum composites for the U.S. Army.[24]

Other developments concerned improvements in SiC fiber making processes. Japan's Nippon Carbon Co. produced SiC fibers derived from polycarbonsilane precursors. The University of Michigan has developed a simple three-step process that can also produce pure highly crystalline SiC fiber. Also discussed was the high cost of SiC fibers, upwards of $5,000 per pound.[25]

Dupont researchers have produced a microcomposite composed of Kevlar and silicon carbide whiskers. The company says that the material has properties that are beneficial in structural applications and could overcome drawbacks associated with Kevlar.[26]

A National Aeronautics and Space Administration brief discussed a new precursor for Si_3N_4. The process for the production of Si_3N_4 involves the thermal decomposition of silicon dimide.[27]

Scientists at the University of Wisconsin report making a silicon compound that has only a pair of bonds rather than the usual four. The divalent silyene could dramatically expand the number and types of commercially feasible silicon compounds.[28]

Outlook

The forecast range of total U.S. demand in the year 2000 was expected to be 25 to 30 million metric tons for industrial sand and gravel. Probable demand was expected to be about 29 million tons. All forecasts were based on previous performances for this commodity within various end uses and contingency factors considered relevant to the future of the commodity.

Since 1987, annual demand for glass sand had fluctuated between 10.0 and 11.1 million tons. The amount of sand consumed for container glass has generally decreased since 1987 mainly because some glass containers were being replaced by aluminum cans and plastic containers and also because the amount of glass being recycled was increasing. Additionally, many manufacturers of container glass were using thinner walls in glass containers, and this has lowered the amount of sand used. However, glass fibers and novel uses for glass may offer new avenues for silica sales for glass.

The amount of flat glass shipped had excellent growth in 1994 finishing close to 10% ahead of 1993. Continued expansion of the light auto and construction industry, near 8.5% each in 1994, helped spur on greater flat glass production. However, 1995 growth was predicted to be slightly negative for flat glass shipments even as flat producers announced several flat glass capacity increases. An interesting development in Japan could eventually have negative affects on flat glass consumption. The Japanese Ministry of Transportation announced that it will lift the ban on thermoplastic resins for passenger car windows. The lifting of the rule is in response to improved coating technology that has been developed to protect resin surfaces from being scratched. Design concerns will not allow this change to plastic quickly but this possibility could eventually result in lower silica consumption for automobile glass.[29]

KMI Corp., Newport, RI, forecasted very positive growth for fiber optic cable for many locations throughout the world. They placed growth at 10% for 1993, compared with 1992, for a total of $3.7 billion. Growth is expected to be particularly strong in most of Asia, Africa, Eastern Europe, and Latin America. Telephone companies use of fiberoptic cable in local loops will have the greatest impact on growth. Worldwide, 29% of the world wide market was held by local loops and this is expected to increase to 47% by 1998.[30]

In other specialty glass news, GE Quartz broke ground on August 4, 1994, for an expansion of its Newark, OH, quartz plant. The quartz glass is essentially a fused quartz that utilizes high quality quartz and is included in the industrial sand and gravel category. The source of the quartz was not revealed.[31] Additionally, an article in Glass Industry magazine related the affect that increased specialty glass variety and production has had in the current capacity tightness in the flat glass market. The glass manufacturers had shifted unused capacity to specialty glass and when flat glass demand improved, the capacity was no longer available.[32] As referenced in the Consumption section of this report, some companies are now planning to install new or reopen mothballed flat capacity.

The domestic fiberglass market began to recover in 1992 after posting decreases from 1988-1991. Imports are increasing but are still less than 10% of domestic consumption while exports increased about 41%, to $392 million, from 1988-1992. The United States-Canada Free-Trade Agreement has helped to double exports of fiberglass during the same period. Additionally, reinforced glass composites also were expected to see strong growth throughout the decade.

Overall, although demand for specialty and fiber glass is expected to increase, the largest tonnage consumers, the container and flat segments, will probably experience small or no total growth. Therefore, demand for glass sand was expected to grow slowly in quantity through the year 2000. Probable demand for glass sand for the year 2000 was forecast to be 11.5 million tons, with a range of 9 to 12.5 million tons.

The use of foundry sand was seen to be dependent mainly on automobile production. Another important factor for the future consumption of virgin foundry sand was the recycling of used foundry sand. The level of recycling, though not clear, was thought to be increasing. Other materials or minerals compete with silica as foundry sand but these other "sands" usually suffer a severe price disadvantage.

As reported in the Japanese press, several automakers were planning expansions of their automaking in the United States. Toyota Motor Corp. plans to raise production in the United States by about 13%, and committed to manufacturing all trucks for sale in the United States in California through its GM joint-venture facility. Mitsubishi Motors Corp. plans to boost production at its U.S. manufacturing base, Diamond Star Motors Corp., to 180,000 units in 1994, a 31% increase over 1993. Isuzu Motor Co. and Fuji Heavy Industries are expanding production to 100,000 vehicles built in the United States, a 30% increase. Nissan Motor Co., Honda Motor Co., and Mazda Motor Co. plan 10%, 25%, and 10% increases in U.S. production, respectively.

Based on these factors: foundry activity (mainly auto related), competing materials, and recycling, the probable forecast for silica foundry sand consumption in the year 2000 was expected to be 7.5 million tons, and the demand range was expected to be 6 to 8 million tons.

Frac sand was consumed near 1993 levels throughout 1994. The Baker-Hughes' cumulative rig count comparing year to year data shows that 1994 stayed ahead of 1993's rig count until September and ended the year slightly behind 1993's week by week comparison. The number of permits issued rose throughout much of 1994 with sharp advances in Texas and Oklahoma. As has been the case when comparing oil and gas drilling, U.S. production of oil will likely suffer as imports continue to control a higher percentage of supply but natural gas production will likely maintain steady increases.

In another important development that could affect domestic frac sand sales, Canadian company Ultrasonic Industrial Sciences Ltd., announced the acquisition of a silica sand mining permit near Peace River, Alberta that could put a significant dent in frac sand imports from the United States. The deposit's total measured and inferred sand reserves approach 48 million tons.[33]

Based on these factors, demand was expected to grow for this end use during the decade, partially due to strong exports and a growing demand for natural gas. Probable demand for hydraulic fracturing sand for the year 2000 was expected to be 1.75 million tons, with a range of 1.6 to 2.0 million tons.

Based on the reports covered in the Current Research and Technology section, it is obvious that specialty silicas will continue to see sustained growth through at least 2000. Assuming that the silica route will be through the chemical and silicon metal categories, it is expected that the chemical and silicon metal categories should see better than average growth, probably in the 2% to 4% annual growth range. This positive forecast would be tempered if the specialty silicas producers are using a silica source other than industrial sand and gravel. The process for each type of silica is highly variable and certainly not well advertised; and therefore, it is difficult to determine the natural source and the processing route for the silica or silicate.

The United States was the largest producer and consumer of silica sand among the market economy countries and was self-sufficient in this commodity. Most of it was produced in the eastern part of the United States, where the premier deposits and major markets are. A significant amount of silica sand also was produced in the West and Southwest, mostly in California and Texas. Domestic production was expected to continue to meet more than 99% of demand well beyond 2000. Imports, mostly from Australia, Canada, and Europe were expected to remain minor.

Because the unit price of silica sand was relatively low, except for a few end uses that required a high degree of processing, the location of silica sand deposits in relation to the market was an important factor that may work for or against a sand producer. Consequently, a significant number of relatively small operations supplied local markets with a limited number of products.

Several factors could affect supply-demand relationships for silica sand. Further increases in the development of substitute materials for glass and cast metals could reduce demand for glass sand and foundry sand. These substitutes, mainly polymers and ceramics, would likely increase demand for ground silica, which is used as a filler in plastics, for glass fibers, which are used in reinforced plastics and for silica either chemically, whole grain or ground, which are used to manufacture ceramics. Also, increased efforts to reduce waste and increase recycling could hinder glass sand demand. However, with advances in high tech materials, silica sand may see increased consumption for fiber optics and other silicon and glass compounds. Although developments could cause demand for silica sand to decrease, the total value of production could increase because of the increased unit value of the more specialized sands.

An increase in the price of oil on the international market would stimulate domestic drilling and extraction from new and old oil deposits. This would increase demand for domestic hydraulic fracturing sand.

Concern over the use of silica as an abrasive due to health concerns and the imposition of stricter legislative and regulatory measures concerning silica exposure could decrease demands in many silica markets. Silica sand for use in the abrasive blast industry was being attacked as a health hazard as marketers of competing materials including garnet, slags, and olivine, pushed the use of their "safer" abrasive medium.

Development of more efficient mining and processing methods are expected to continue. This will enhance development of lower grade silica sand deposits closer to markets but not presently mined. Such developments are expected to increase silica sand reserves.

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TABLE 1
SALIENT U.S. INDUSTRIAL SAND AND GRAVEL STATISTICS 1/ 2/

		1990	1991	1992	1993	1994
Sold or used:						
Sand:						
Quantity	thousand metric tons	24,500	22,300	23,700	24,500	25,500
Value	thousands	$421,000	$378,000	$415,000	$436,000	$466,000
Gravel:						
Quantity	thousand metric tons	1,320	961	1,520	1,700	1,790
Value	thousands	$15,300	$12,900	$19,800	$18,500	$22,400
Total industrial:						
Quantity	thousand metric tons	25,800	23,200	25,200	26,200	27,300
Value	thousands	$436,000	$390,000	$434,000	$454,000	$488,000
Exports:						
Quantity	thousand metric tons	1,050	1,490	1,340	1,750	1,880
Value	thousands	$83,800	$107,000	$90,400	$91,000	$102,000
Imports for consumption:						
Quantity	thousand metric tons	66	83	164	44	22
Value	thousands	$3,150	$932	$2,450	$2,440	$1,790

1/ Puerto Rico excluded from all industrial sand and gravel statistics.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 2
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY GEOGRAPHIC REGION 1/

Geographic region	1993				1994			
	Quantity (thousand metric tons)	Percent of total	Value (thousands)	Percent of total	Quantity (thousand metric tons)	Percent of total	Value (thousands)	Percent of total
Northeast:								
New England	102	(2/)	$4,420	1	93	(2/)	$2,370	(2/)
Middle Atlantic	2,430	9	39,700	9	2,330	9	42,600	10
Midwest:								
East North Central	9,760	37	147,000	32	10,300	38	159,000	32
West North Central	1,770	7	37,600	8	1,910	7	39,900	8
South:								
South Atlantic	3,910	15	71,700	16	4,010	15	77,400	16
East South Central	1,280	5	19,400	4	1,350	5	20,400	4
West South Central	3,750	14	68,700	15	3,940	14	79,500	16
West:								
Mountain	1,230	5	19,500	4	1,440	5	23,100	5
Pacific	2,010	8	46,200	10	1,970	7	44,500	9
Total	26,200	100	454,000	100	27,300	100	488,000	100

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

TABLE 3
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	1993		1994	
	Quantity	Value	Quantity	Value
Alabama	559	6,800	610	7,160
Arizona	W	W	W	W
Arkansas	642	7,600	W	W
California	1,800	41,700	1,740	39,400
Colorado	W	W	W	W
Connecticut	W	W	W	W
Florida	504	5,910	540	6,120
Georgia	491	7,940	440	7,040
Idaho	W	W	481	7,410
Illinois	4,220	61,700	4,420	65,700
Indiana	W	W	120	1,010
Iowa	W	W	W	W
Kansas	W	W	W	W
Louisiana	465	9,360	454	9,320
Maryland	W	W	W	W
Massachusetts	2	42	W	W
Michigan	2,570	25,100	2,870	31,300
Minnesota	W	W	W	W
Mississippi	W	W	W	W
Missouri	520	9,390	559	9,970
Montana	W	W	W	W
Nebraska	W	W	W	W
Nevada	480	W	572	W
New Jersey	1,830	28,600	1,690	30,600
New York	W	W	W	W
North Carolina	1,340	18,600	1,460	24,200
North Dakota	W	W	W	W
Ohio	1,360	27,500	1,260	27,700
Oklahoma	1,210	23,200	1,230	24,000
Pennsylvania	W	W	W	W
Rhode Island	W	W	W	W
South Carolina	749	19,000	699	18,100
Tennessee	644	11,700	659	11,600
Texas	1,430	28,600	1,570	37,900
Virginia	W	W	W	W
Washington	W	W	W	W
West Virginia	W	W	W	W
Wisconsin	1,480	31,400	1,630	32,400
Other	3,930	90,300	4,320	96,500
Total	26,200	454,000	27,300	488,000

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 4
INDUSTRIAL SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 1994, BY SIZE OF OPERATION 1/

Size range	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total
Less than 25,000	27	18	289	1
25,000 to 49,999	18	12	617	2
50,000 to 99,999	31	20	1,960	7
100,000 to 199,999	29	19	3,660	13
200,000 to 299,999	9	6	2,060	8
300,000 to 399,999	13	9	4,190	15
400,000 to 499,999	8	5	3,220	12
500,000 to 599,999	3	2	1,480	6
600,000 to 699,999	7	4	4,080	15
700,000 and over	7	4	5,770	21
Total	152	100	27,300	100

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 5
NUMBER OF INDUSTRIAL SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 1994, BY GEOGRAPHIC REGION

Geographic region	Mining operations on land				Dredging operations	Total active operations
	Stationary	Portable	Stationary and portable	No plants or unspecified		
Northeast:						
New England	2	--	--	--	1	3
Middle Atlantic	9	--	3	1	4	17
Midwest:						
East North Central	37	1	--	1	2	41
West North Central	5	--	--	--	6	11
South:						
South Atlantic	16	--	1	3	5	25
East South Central	9	--	1	--	2	12
West South Central	8	--	1	1	12	22
West:						
Mountain	8	1	1	--	--	10
Pacific	8	--	--	2	1	11
Total	102	2	7	8	33	152

INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 1994, BY MAJOR END USE 1/

(Thousand metric tons and thousand dollars)

Major use	Northeast			Midwest			South			West			U.S. total		
	Quantity	Value	Value per ton	Quantity	Value	Value per ton	Quantity	Value	Value per ton	Quantity	Value	Value per ton	Quantity	Value	Value per ton
Sand:															
Glassmaking:															
Containers	975	16,000	$16.39	1,840	18,500	$10.04	1,890	27,400	$14.49	1,260	26,200	$20.86	5,960	88,000	$14.77
Flat (plate and window)	W	W	15.14	832	7,910	9.50	1,480	21,400	14.48	W	W	16.34	2,610	34,200	13.10
Specialty	W	W	19.82	321	5,150	16.04	398	7,060	17.74	W	W	30.00	959	17,200	17.95
Fiberglass (unground)	W	W	14.30	365	4,990	13.67	323	8,040	24.88	W	W	20.57	779	14,500	18.60
Fiberglass (ground)	--	--	--	W	W	40.16	261	10,300	39.39	W	W	16.34	363	12,700	35.01
Foundry:															
Molding and core	342	6,790	19.86	5,190	66,300	12.77	1,130	14,200	12.62	71	1,550	21.83	6,730	88,800	13.20
Molding and core facing (ground)	--	--	--	W	W	46.31	--	--	--	--	--	--	W	W	46.31
Refractory	W	W	15.69	W	W	6.82	8	375	46.88	1	12	12.00	61	857	14.05
Metallurgical:															
Silicon carbide	--	--	--	W	W	14.31	--	--	--	--	--	--	W	W	14.31
Flux for metal smelting	--	--	--	W	W	9.97	W	W	5.17	W	W	8.60	53	478	9.02
Abrasives:															
Blasting	143	3,950	27.65	258	6,470	25.07	944	20,600	21.81	166	5,090	30.69	1,510	36,100	23.89
Scouring cleansers (ground)	--	--	--	W	W	46.50	W	W	36.00	--	--	--	W	W	44.86
Sawing and sanding	W	W	19.00	--	--	--	(2/)	2	55.67	--	--	--	W	W	20.00
Chemicals (ground and unground)	W	W	18.06	W	W	12.29	227	5,640	24.84	55	1,130	20.53	603	11,200	18.60
Fillers (ground):															
Rubber, paints, putty, etc.	W	W	79.86	W	W	94.69	36	7,300	202.75	--	--	--	68	10,300	151.97
Whole grain fillers/building products	105	2,810	26.80	528	14,100	26.64	445	14,900	33.44	175	4,880	27.91	1,250	36,600	29.24
Ceramic (ground):															
Pottery, brick, tile, etc.	W	W	37.14	148	7,400	50.03	W	W	49.26	--	--	--	259	12,700	48.91
Filtration:															
Water (municipal, county, local, etc.)	74	1,660	22.42	69	2,130	30.83	135	2,250	16.64	74	2,580	34.85	352	8,610	24.47
Swimming pool, other	W	W	58.50	11	773	70.27	6	411	68.50	W	W	77.08	23	1,540	67.00
Petroleum industry:															
Hydraulic fracturing	--	--	--	1,320	42,300	32.10	310	9,120	29.42	27	782	28.96	1,650	52,200	31.54
Well packing and cementing	--	--	--	12	1,640	136.58	14	215	15.36	15	252	16.80	41	2,110	51.37
Recreational:															
Golf course (greens and traps)	74	1,140	15.34	168	3,460	20.60	179	1,510	8.45	166	3,310	19.93	587	9,420	16.04
Baseball, volleyball, play sand, beaches	108	1,120	10.34	9	84	9.33	52	517	9.94	2	41	20.50	172	1,760	10.23
Traction (engine)	W	W	13.95	113	1,130	9.97	119	1,420	11.93	W	W	22.40	292	3,540	12.12
Roofing granules and fillers	30	627	20.90	W	W	3.24	130	1,260	9.68	W	W	14.86	217	2,150	9.92
Other (ground silica)	21	785	37.38	W	W	23.57	W	W	31.30	70	1,140	16.29	46	1,700	27.96
Other (whole grain)	429	7,940	13.18	568	7,850	20.26	302	6,310	21.21	474	9,110	19.44	942	18,800	20.04
Total or average	2,340	43,300	18.54	11,900	196,000	16.50	8,490	165,000	19.44	2,870	61,500	21.47	25,500	466,000	18.23
Gravel:															
Silicon, ferrosilicon	--	--	--	W	W	12.74	W	W	14.06	--	--	--	568	7,920	13.94
Filtration	38	1,440	38.00	W	W	10.66	38	1,150	30.29	W	W	91.49	157	3,450	21.96
Nonmetallurgical flux	--	--	--	--	--	--	--	--	--	497	5,720	11.50	497	5,720	11.50
Other uses, specified	47	221	4.70	224	795	3.55	254	3,920	15.43	39	378	9.69	564	5,310	9.41
Total or average	85	1,670	19.59	357	2,320	5.42	807	12,300	17.35	536	6,090	11.37	1,790	22,400	11.88
Grand total or average	2,420	45,000	18.57	12,300	199,000	16.22	9,290	185,000	19.08	3,400	67,600	19.89	27,300	488,000	17.86

W Withheld to avoid disclosing company proprietary data; included in "Total".

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

TABLE 7
U.S. EXPORTS OF INDUSTRIAL SAND AND GRAVEL, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	F.a.s. value 2/	Quantity	F.a.s. value 2/
North America:				
Bermuda	(3/)	24	10	62
Canada	1,400	17,800	1,480	20,100
Mexico	43	1,720	159	2,900
Panama	12	229	11	166
Other	3	834	11	523
Total	1,450	20,700	1,670	23,800
South America:				
Argentina	4	649	29	1,280
Brazil	78	530	12	900
Peru	2	144	3	290
Venezuela	(3/)	132	4	649
Other	2	14	1	589
Total	86	1,990	48	3,710
Europe:				
Germany	34	3,760	22	12,600
Italy	3	701	4	1,020
Netherlands	14	5,040	6	3,840
United Kingdom	3	1,070	24	2,270
Other	20	6,630	15	4,630
Total	74	17,200	71	24,300
Asia:				
Hong Kong	1	243	11	7,050
Japan	84	39,100	43	29,700
Korea, Republic of	10	3,040	7	2,980
Singapore	8	3,880	5	2,400
Taiwan	22	3,100	19	4,780
Other	1	904	4	1,960
Total	126	50,100	88	48,900
Middle East and Africa:				
Total	9	572	5	628
Oceania:				
Australia	2	462	2	547
Other	(3/)	56	(3/)	115
Total	2	518	2	662
Grand total	1,750	91,000	1,880	102,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL SAND, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	C.i.f. value 2/	Quantity	C.i.f. value 2/
Australia	42	1,760	11	644
Belgium	(3/)	5	--	--
Canada	(3/)	28	1	103
France	(3/)	19	--	--
Germany	1	76	(3/)	145
Guyana	--	--	8	150
Italy	(3/)	18	(3/)	36
Japan	(3/)	147	(3/)	234
Mexico	--	--	(3/)	2
Solomon Islands	(3/)	7	--	--
Sweden	1	329	2	415
United Kingdom	(3/)	2	(3/)	7
Venezuela	(3/)	45	(3/)	57
Total	44	2,440	22	1,790

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 9
INDUSTRIAL (SILICA) SAND AND GRAVEL: WORLD PRODUCTION BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina	335 r/	374	340 r/	396 r/	380
Australia e/	2,000	2,000	2,000	2,000	2,500
Austria	818	2,090	5,880	4,300 r/	6,460 4/
Belgium	2,560	2,550	2,480 e/	2,480 e/	2,480
Bosnia and Herzegovina e/	XX	XX	50	50	50
Brazil e/	2,700	2,700	2,700	2,700	2,700
Canada	2,080	1,500	1,750	1,600 e/	1,600
Chile e/	300	300	300	300	300
Croatia e/	XX	XX	150	100	100
Cuba e/	500	500	450	400	350
Denmark (sales)	333 r/	325 r/ e/	315 r/ e/	315 r/	315
Ecuador e/	52	33	51	46	45
Egypt 5/	507	500	500 e/	500 e/	500
Estonia e/ 6/	XX	XX	30	25	25
Finland	276	201	169	167 r/	162 4/
France e/	3,500	3,500	6,300	5,400 r/	6,000
Germany:					
Western states	9,400	XX	XX	XX	XX
Eastern states	1,850 e/	XX	XX	XX	XX
Total	11,200 e/	11,000 e/	10,700	9,770 r/	10,000
Greece	94	--	--	--	--
Guatemala	30	17	34	27 e/	56 4/
Hungary	1,250	781	844	780 e/	750
Iceland e/	5	5	5	5	5
India	1,140	1,920	1,320 r/	1,290 r/	1,300
Indonesia	165	429	400 e/	240 r/	240
Iran 7/	870 e/	832	756	932 r/	950
Ireland e/	7	7	7	7	8
Israel	85	60	60	60 e/	60
Italy e/	4,300	4,200	4,000	4,000	4,000
Jamaica	17	16	16	21 r/	18 4/
Japan	4,440	4,340	3,840 r/	3,880	3,940 4/
Kenya e/	12	12	12	12	12
Korea, Republic of e/	2	1	2	2	2
Latvia e/ 6/	XX	XX	110 r/	90 r/	90
Liberia e/	5	--	--	--	--
Lithuania e/ 6/	XX	XX	80	60	60
Malaysia	687	668	579	355 r/	231 4/
Mexico	1,170	1,200	1,130	1,310 r/	1,360 4/
Namibia e/	--	--	-- r/	-- r/	--
Netherlands e/	25,100 4/	25,000	20,000	20,000	20,000
New Caledonia e/	31	31	31	31	39
New Zealand	545	594	500 r/	720 r/	750
Norway e/	800 r/	800 r/	900 r/	900 r/	900
Pakistan	131	151	135	168 r/	170
Panama	15	18	23	23 e/	23
Paraguay e/	2,000	2,000	2,000	2,000	2,000
Peru	100 e/	150	152	152 e/	150
Philippines	256 r/	532	500	828 r/	800
Portugal e/	5	5	5	5	5
Serbia and Montenegro	XX	XX	613 r/	185 r/	200
Slovenia e/	XX	XX	300	200	200
South Africa, Republic of	1,990	2,070	1,750	1,740 r/	1,920 4/
Spain e/	2,200	2,200	2,200	2,200	2,000
Sweden e/	1,230 r/	1,470 r/	1,430 r/	1,500 r/ e/	1,500
Tanzania	6	4	4	4 e/	4
Thailand	422	657 r/	594 r/	459 r/	471
Turkey e/ 8/	469 4/	358 e/	510	300 r/	315
United Kingdom	4,300 e/	3,900	3,620	4,000 e/	3,600
United States (sold or used by producers)	25,800	23,200	25,200	26,200	27,900 4/
Venezuela	443	343	703	753 r/	780

See footnotes at end of table.

TABLE 9--Continued
INDUSTRIAL (SILICA) SAND AND GRAVEL: WORLD PRODUCTION BY COUNTRY 1/ 2/

(Thousand metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Yugoslavia 9/	2,450	2,100	XX	XX	XX
Zimbabwe 10/	63	70	77	80 e/	130
Total	110,000 r/	108,000 r/	109,000 r/	106,000 r/	111,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 20, 1995.

3/ In addition to the countries listed, Angola, Antigua and Barbuda, The Bahamas and China, among others, produce industrial sand, but current available information is not adequate to formulate estimates of production levels.

4/ Reported figure.

5/ Fiscal years beginning July 1 of that stated.

6/ Formerly part of the U.S.S.R., which was dissolved in Dec. 1991. Information was inadequate to formulate reliable estimates of production prior to 1992.

7/ Fiscal years beginning Mar. 21 of that stated.

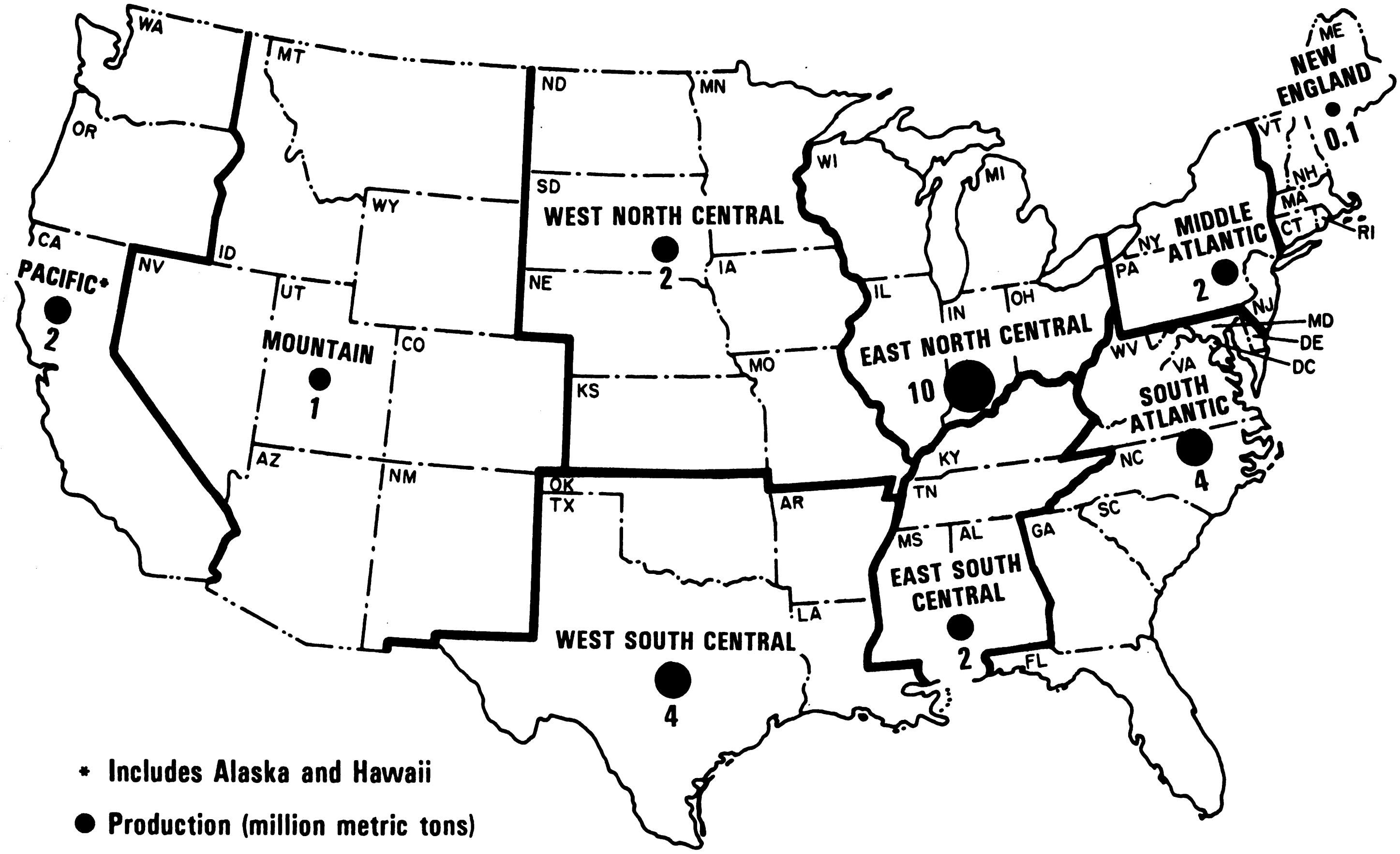
8/ Washed product.

9/ Dissolved in Apr. 1992.

10/ Includes rough and ground quartz as well as silica sand.

FIGURE 1

PRODUCTION OF INDUSTRIAL SAND AND GRAVEL IN THE UNITED STATES IN 1994, BY GEOGRAPHIC REGION



SELENIUM AND TELLURIUM

By Robert D. Brown, Jr.

Primary selenium was produced domestically as a byproduct of copper refining in 1994; there was no production of secondary (recycled) selenium. Five copper refineries generated selenium-containing anode slimes. Two of the refineries recovered commercial grade selenium, one recovered a semirefined filter cake, which it shipped to Asia for further refining, and two exported anode slimes for refining. Domestic production, excluding exported anode slimes, increased 27% in 1994, to 360 metric tons. The increase was attributed reportedly to improvements to one company's purification circuit and a greater concentration of selenium in the ores.[1] The value of U.S. production was $3.8 million.

Apparent consumption of selenium increased 15% in 1994 in response to increased demand in the chemical and glass industries. Other uses included electronics (including photoreceptors), agricultural feed additives, metallurgical applications, and catalysts. Selenium use as a photoreceptor for plain paper copiers has been decreasing in favor of organic compounds.

All selenium-containing scrap generated was exported for reprocessing. World secondary production was estimated at 250 tons of selenium. World refinery production increased 7%, to 1,880 tons; Japan, the United States, Canada, Belgium, and Germany were the largest producers in order of output.

Tellurium was recovered by one company from anode slimes generated in the electrolytic refining of copper and from soda slag skimmings generated in lead refining. There was no domestic production of secondary tellurium, but some scrap was exported for recycling. Production data are company proprietary. Domestic apparent consumption was believed to have increased slightly in 1994, according to the Selenium-Tellurium Development Association (STDA). About 50% of consumption was for free-machining additives to steel. Other uses included catalysts, chemical uses, nonferrous alloys, photoreceptors, and thermoelectric devices.

World reserves and resources for selenium and tellurium are based on copper reserves and resources using the following factors; for selenium, 0.64 kg/mt copper for Canada and 0.215 kg/mt copper for the rest of the world. For tellurium, 0.065 kg/mt. World reserves for selenium are 70,000 tons and resources are 130,000 tons. For tellurium, world reserves are 20,000 tons and resources 38,000 tons. Chile, the United States, and Canada possess the largest reserves for both metals in order of magnitude.

Domestic Data Coverage

Domestic production, shipments, and stock data are collected by a voluntary survey of the domestic producers of selenium and tellurium. The selenium production canvass was sent to the three known producers and tellurium to the sole producer. All companies responded, but some company proprietary data were not released.

Production

Selenium was recovered from anode slimes generated in the electrolytic production of copper. Domestic production increased 27% from 1993 reportedly owing to one company improving its electrolyte purification facility and having a greater concentration of selenium in its ores.[2] Five domestic copper refineries generated selenium-containing slimes, but only three recovered selenium; ASARCO Incorporated at Amarillo, TX; Phelps Dodge Refining Corp. at El Paso, TX; and Rio Tinto Zinc at its Kennecott refinery in Magna, UT. One producer exported semirefined selenium (90% selenium content) for toll-refining in Asia. Selenium-containing slimes from the other two refineries were exported for processing.

Most domestic selenium was produced as commercial-grade materials, averaging a minimum of 99.5% selenium and available in various forms including shot, lumps, or powder or as pigment-grade powder having a minimum 99.8% selenium content.

Commercial grade tellurium and tellurium dioxide were produced by ASARCO at Amarillo, mainly from copper anode slimes, but also from lead refinery skimmings. ASARCO also produced high purity tellurium (99.999% purity) and selenium (99.999% purity) and other high purity metals and compounds at its plant in Denver, CO. Detector-grade tellurium (99.99999% purity) was produced by Cabot Performance Metals, Revere, PA.

Consumption

Selenium demand by end use can be divided broadly into five categories; electronic (includes photoconductor uses), glass manufacturing, pigments and chemicals, and other, including agricultural and metallurgical uses. In electronics, a large end-use market, high-purity selenium compounds were used principally as photoconductors on the drums of plain paper copiers. Photoreceptors have been the largest application for selenium over the past decade. However, the percentage of total selenium used for photoreceptors has dropped to nearly 30% and is expected to drop 8%-10% per year until 1997, before leveling off. Selenium compounds are being replaced by organic photoreceptor compounds (OPC), which reportedly offer better performance and lower cost at printing speeds under 80 pages per minute and comparable cost and performance at faster rates. OPC's also are free of the environmental concerns associated with the disposal of selenium compounds.[3] Other electronic uses included rectifier and photoelectric applications.

In glass manufacturing, selenium is used principally as a decolorant in container glass and other soda-lime silica glasses. The addition of selenium under weak oxidizing conditions adds a pink color to the glass that combines with the green color imparted by ferrous ions to create a neutral grey color that has low perceptibility to the human eye. Selenium is also used to reduce solar heat transmission in architectural plate glass and to add red color to glass, such as that used in traffic lights. Glass manufacturing accounted for about 30% of the selenium market in 1994.

In pigment applications, selenium is used to produce color changes in cadmium sulfide-based pigments. With increasing substitution of selenium for sulfur, the yellow cadmium pigment becomes redder. Sulfoselenide red pigments have good heat stability and are used in ceramics and plastics, as well as in paints, inks, and enamels. Because of the relatively high cost and toxicity of cadmium-based pigments, their use is generally restricted to applications requiring long life, brilliance, and high thermal stability and chemical resistance. Pigments were about 18% of the domestic market.

Chemical uses of selenium, including industrial, pharmaceutical, agricultural, and biological applications, accounted for 10% of domestic usage. Dietary supplements for livestock are the largest agricultural usage, though selenium also may be added to fertilizer, a practice that is more prevalent outside the United States. Small quantities of selenium also may used as human food supplements; selenium has been recognized as an essential nutrient for human health. The principal pharmaceutical use of selenium is in antidandruff hair shampoos. Miscellaneous industrial chemical uses include lubricants, rubber compounding, and catalysts.

Metallurgical and miscellaneous uses comprised the remaining 12% of the market. Selenium is added to steel, copper, and lead alloys to improve machinability and casting and forming properties. Several domestic producers of rolled steel bar produce both leaded and selenium-bearing free-machining rod. Selenium-containing free-cutting steels are generally cost competitive only when used with high-speed automatic machine tools.

Selenium is added to low-antimony lead alloys used in the support grids of lead-acid storage batteries. The addition of 0.02% selenium by weight as a grain nucleant improves the casting and mechanical properties of the alloy. The quantity of selenium consumed in this application has been greatly affected by technological changes in battery grid manufacture. Development of low-maintenance batteries in the early 1970's encouraged the use of low-antimony grid alloys requiring selenium. Since 1975, lead-cadmium maintenance-free automotive batteries have captured a greater share of the automotive battery market. More recently, hybrid batteries, which employ low-antimony lead positive plates and lead-cadmium negative plates, have been gaining in usage.

Tellurium is used principally as an alloying element in the production of free-machining low-carbon steels, where additions of up to 0.1% tellurium, usually in conjunction with lead, greatly improve machinability. Similarly, the addition of tellurium to copper and other nonferrous alloys improves their machinability, strength, and corrosion resistance. Tellurium catalysts are used chiefly for oxidation of organic compounds but are used also in hydrogenation, halogenation, and chlorination reactions. Tellurium chemicals are used as curing and accelerating agents in rubber compounding. Electronic semiconductor applications for high-purity tellurium include its use with selenium as a photoconductor in plain paper copiers, in thermoelectric and photoelectric devices, and in optical disc storage systems. Mercury-cadmium-telluride (MCT) is used as a sensing material for thermal imaging devices.

Thermoelectric cooling devices, based on bismuth-telluride semiconducting materials, are finding wider application in electronic and consumer applications. Thermoelectric cooling devices consist of a series of couples of different semiconducting materials, which when connected to a direct current, cause one side of the thermoelement to cool while the other side evolves heat. The warm side is connected to a heat sink to dissipate the heat. Thermoelectric coolers are used for infrared detectors, integrated circuits, medical instrumentation, laser diodes, etc., as well as consumer products such as portable coolers.

Apparent domestic demand for tellurium, calculated from production, stock, and trade data, increased slightly in 1994. The largest use for tellurium was as an additive to free-machining steel, about 50% of the market. Chemicals and catalyst usage was about 25% of the market. Additives to nonferrous alloys and photoreceptor applications each used 20%. Other uses were about 5%.

Prices

The domestic producer price for selenium averaged $4.75 per pound in 1994. The producer price for tellurium was $27 per pound.

World Review

The Fifth International Symposium on the Uses of Selenium and Tellurium was held in May in Brussels, Belgium. The 3-day symposium featured 74 presentations on agriculture, chemical uses, environmental issues, metallurgy, and photoelectric applications. The proceedings are available from the STDA.[4]

World production and consumption data for tellurium were limited. According to STDA statistics, the supply increased at a faster rate than demand. STDA data reflect only shipments and inventories from companies that accounted from about 70% of the Western World supply. Supply and demand have been in balance for several years and each were estimated to have averaged 220 tons per year over the past 3 years. Production figures for many countries are withheld because of the need to conceal company proprietary data.

Current Research and Technology

Selenium has been tested as a free-machining additive to replace lead in plumbing brass. Two industry consortia are evaluating several different compositions that use varying contents of bismuth and other additives including selenium. One alloy containing 2% bismuth and 1% selenium showed machinability near that of leaded brass. However, the limited supply for bismuth and selenium must be taken into consideration in determining an alloy that would be commercially successful.[5]

Outlook

Selenium is dependent upon copper production; and in the past 5 years, the supply has exceeded demand. Because it is recovered as a byproduct, selenium output cannot be easily adjusted to meet market conditions and is subject to supply and price fluctuations. Although several new uses have been developed, they have not impacted the overall demand for selenium. Demand for selenium in photoreceptors is likely to continue to decline as the cost of using organic compounds decreases. The only possible large increase in demand would come from use as an additive to plumbing brass, but this is still under development.

Tellurium supply and demand have remained in balance since 1990. This situation is likely to continue as there are no large increases foreseen in either consumption of production for the next 5 years. Demand for high purity tellurium may increase for solar cells, but would not have a major impact on demand. Little information is available on the selenium or tellurium content of new ore bodies.

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[1] ASARCO Company Annual Report 1994.

[2] Reference cited in footnote.[1]

[3] Springett, B. F. Status of Selenium Alloys in Non-Impact Printers and Photocopiers. Paper in Proceedings of the 5th International Symposium on the Uses of Selenium and Tellurium (Brussels, Belgium, May 8-10, 1994). STDA, 1994, pp. 187-190.

[4] STDA
301 Borgtstraat
B-1850, Grimbergen, Belgium
Tel. (322) 252-1490
Fax: (322) 252-2775

[5] The Bulletin of the Selenium-Tellurium Development Association. Selenium-Containing Pb-Free, Free-Cutting Copper Alloys for Plumbing Fixtures. Nov. 1994, pg. 4.2

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publication

Selenium. Ch. in Mineral Commodity Summaries, annual.

Other Sources

Bulletin of the Selenium-Tellurium Development Association.
ABMS Nonferrous Metal Data.
American Metal Market.
Journal of Metals.
Metal Bulletin (London).
Platt's Metals Week.

TABLE 1
SALIENT SELENIUM AND TELLURIUM STATISTICS 1/

(Kilograms of contained metal unless otherwise specified)

	1990	1991	1992	1993	1994
SELENIUM					
United States:					
Production, primary refined	287,000	260,000	243,000 2/	283,000 2/	360,000
Shipments to consumers	250,000	275,000	221,000	258,000	302,000
Exports, metal, waste and scrap	207,000	210,000	175,000	261,000	246,000
Imports for consumption 3/	381,000	344,000	371,000	382,000	411,000
Apparent consumption, metal 4/	530,000	510,000	490,000	460,000	530,000
Dealers' price, average per pound, commercial grade 5/	$5.82	$5.41	$5.13	$4.90	$4.75
World: Refinery production	1,770,000 r/	1,640,000 r/	1,770,000 r/	1,760,000 r/	1,880,000
TELLURIUM					
United States:					
Imports for consumption 6/	34,000	29,300	48,400	45,000	27,400
Producer price quote, yearend, commercial grade, per pound	$31.00	$32.00	$35.00	$32.00	$26.00

e/Estimated. r/Revised.

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/Includes semi-refined selenium produced by one company and exported for refining.

3/Includes unwrought and waste and scrap and selenium dioxide.

4/Calculated using reported shipments, imports of selenium metal, and estimated exports of selenium metal, excluding scrap.

5/Source: Platt's Metals Week. Calculated from published price ranges.

6/Includes only unwrought and waste and scrap.

TABLE 2
U.S. EXPORTS OF SELENIUM METAL AND WASTE AND SCRAP 1/

(Kilograms, contained selenium)

Country	1993		1994	
	Quantity	Value	Quantity	Value
Australia	5,120	$55,600	11,400	$36,100
Brazil	10,600	$167,000	15,400	246,000
China	10,200	3,260	--	--
Hong Kong	39,500	342,000	--	--
Japan	29,700	272,000	4,600	58,100
Mexico	20,300	210,000	45,600	708,000
Netherlands	11,300	65,000	28,900	307,000
Philippines	58,700	412,000	115,000	488,000
Spain	11,300	6,250	--	--
United Kingdom	21,700	22,400	626	10,000
Venezuela	14,400	98,400	2,210	37,400
Other	28,600 r/ 2/	542,000 r/ 2/	21,400	386,000
Total	261,000	2,200,000	246,000	2,280,000

r/Revised.

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/Unspecified group of countries differs from that in the 1993 Annual Report.

Source: Bureau of the Census.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF SELENIUM 1/

(Kilograms, contained selenium)

Class and country	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Unwrought and waste and scrap:				
Belgium	35,200	$1,470,000	40,000	$1,700,000
Canada	146,000	3,160,000	174,000	3,400,000
Finland	13,400	119,000	9,710	81,300
Germany	11,300	139,000	6,960	75,200
Japan	30,400	1,140,000	39,300	1,500,000
Philippines	108,000	597,000	103,000	511,000
Sweden	10,000	122,000	--	--
United Kingdom	1,790	34,200	17,500	135,000
Other	11,600	110,000	5,650	28,400
Total	367,000	6,880,000	396,000	7,420,000
Selenium dioxide: 2/				
Germany	7,010	62,200 r/	8,000	83,900
United Kingdom	5,770	75,800 r/	6,540	80,900
Other	1,740	19,600 r/	709	8,710
Total	14,500	158,000 r/	15,300	173,000
Grand total	382,000	7,040,000 r/	411,000	7,600,000

r/Revised.

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/Figures adjusted by the U.S. Bureau of Mines.

Source: Bureau of the Census.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF TELLURIUM 1/ 2/

(Kilograms, gross weight)

Class and country	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Unwrought and waste and scrap:				
Belgium	14,500	$1,100,000	1,930	$164,000
Canada	5,150	393,000	3,400	239,000
France	356	4,550	1,080	21,400
Germany	5,780	453,000	294	57,600
Japan	7,250	592,000	9,530	658,000
Philippines	9,110	457,000	1,790	53,500
Russia	100	12,400	1,040	134,000
United Kingdom	2,230	101,000	7,420	205,000
Other	478	65,900	892	43,000
Total	45,000	3,180,000	27,400	1,570,000

1/Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/Listed as "tellurium" under the Harmonized Tariff System, and grouped together with boron. However, imports of boron are thought to be very small, relative to tellurium.

Source: Bureau of the Census.

TABLE 5
SELENIUM: WORLD REFINERY PRODUCTION, BY COUNTRY 1/ 2/

(Kilograms, contained selenium)

Country3/	1990	1991	1992	1993	1994e/
Belgium e/	250,000	250,000	250,000	250,000	250,000
Canada 4/	342,000	207,000	294,000	295,000 e/	300,000
Chile	49,400	50,600	50,000 e/	49,500 e/	45,000
Finland	31,200	35,200 r/	30,000	30,400 r/	30,500
Germany e/	125,000	110,000	125,000	120,000	120,000
India e/	3,840 5/	4,000	9,700 r/	13,500 r/	14,000
Japan	495,000	537,000	573,000	541,000	595,000
Mexico	12,200	2,800	400	– r/	–
Peru	8,910	12,400	14,400	14,400 e/	14,000
Philippines e/ 6/	55,600 r/	60,000	60,000	40,000	40,000
Serbia and Montenegro e/ 7/	XX	XX	57,800 r/	45,500 r/ e/	40,000
Sweden	29,000	23,000	32,000 r/	50,000 r/	50,000
United States	287,000	260,000	243,000 8/	283,000 8/	360,000 5/ 8/
Yugoslavia 7/ 9/	59,200	64,100 r/	XX	XX	XX
Zambia 10/	21,700	21,900	31,800	27,000 r/	25,000
Zimbabwe	2,300 e/	2,550	1,740	1,110 r/	1,000
Total	1,770,000	1,640,000	1,770,000	1,760,000	1,880,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three sigificant digits; data may not add to totals shown.

2/ Insofar as possible, data relate to refinery output only; thus, countries that produced selenium contained in copper ores, copper concentrates, blister copper and/or refinery residues, but did not recover refined selenium from these materials indigenously were excluded to avoid double counting. Table includes data available through Apr. 7, 1995.

3/ In addition to the countries listed, Australia, and the former U.S.S.R. produced refined selenium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Australia is known to produce selenium in intermediate metallurgical products and has facilities to produce elemental selenium. In addition to having facilities for processing imported anode slimes for the recovery of selenium and precious metals, the United Kingdom has facilities for processing selenium scrap.

4/ Excludes selenium intermediates exported for refining.

5/ Reported figure.

6/ Incomplete; data shown are for primary production at Philippine Associated Smelting and Refining Corp.

7/ All production in Yugoslavia from 1990-91 came from Serbia and Montenegro.

8/ Includes production of semi-refined selenium exported for further refining.

9/ Dissolved in Apr. 1992.

10/ Data are for year beginning Apr. 1 of year stated. Gross weight, purity unknown.

TABLE 6
TELLURIUM: WORLD REFINERY PRODUCTION, BY COUNTRY 1/ 2/

(Kilograms, contained tellurium)

Country 3/	1990	1991	1992	1993	1994 e/
Canada 4/	9,860	12,400	21,800	24,000 r/ e/	27,000
Japan	49,700	57,200	57,200	46,800	48,000
Peru	7,840	13,400	18,600	18,600	18,600
United States	W	W	W	W	W

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Insofar as possible, data relate to refinery output only; thus, countries that produced tellurium contained in copper ores, copper concentrates, blister copper, and/or refinery residues, but did not recover refined tellurium are excluded to avoid double counting. Table is not totaled because of the exclusion of data from major world producers, notably the former U.S.S.R. and the United States. Table includes data available through Apr. 14, 1995.

3/ In addition to the countries listed, Australia, Belgium, Chile, Germany, the Philippines, and the former U.S.S.R. are known to produce refined tellurium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels.

4/ Excludes tellurium intermediates exported for refining.

SILICON

By Larry D. Cunningham

Silicon (Si) is a light chemical element with metallic and nonmetallic characteristics. In nature, silicon combines with oxygen and other elements to form silicates. Silicon in the form of silicates constitutes more than 25% of the Earth's crust. Silica is a silicate consisting entirely of silicon and oxygen. Silica (SiO_2) as quartz or quartzite is used to produce silicon-base products for the aluminum, chemical, iron, and steel industries.

Silicon metal and ferrosilicon are referred to by the approximate percentage of silicon contained in the material and by the maximum amount of trace impurities present. There are two standard grades of ferrosilicon, with one grade approximately 50% silicon and the other 75% silicon by weight. Almost all ferrosilicon products are consumed by the iron and steel industry.

Metallurgical-grade silicon metal is used by the primary aluminum, secondary aluminum, and chemical industries. The products sold to these industries vary considerably in their specifications. The chemical and primary aluminum industries generally require more stringent specifications than those of the secondary aluminum industry. In addition, the chemical industry requires that the metal be ground into a fine powder rather than the lump form used by the aluminum industry.

The average annual dealer import price for ferrosilicon increased from that of 1993, while that for silicon metal decreased. Based on contained silicon, overall domestic silicon production increased to about 390,000 metric tons and consumption of silicon increased to about 610,000 tons.

Overall U.S. trade volume, gross weight, of silicon exports was virtually unchanged, while overall trade volume of silicon imports increased by more than 10%. The President of the United States granted General System of Preferences (GSP) status to Kazakhstan, Romania, Ukraine, and the Republic of South Africa.

Legislation and Government Programs

In October, it was reported that Sematech, an 11 member company consortium of semiconductor manufacturers, planned to relinquish government funding by late 1996. Sematech was founded in 1987 to improve U.S. company competitiveness in computer chip manufacturing technology. The U.S. Department of Defense provides about $90 million per year to Sematech's research. The consortium plans to continue its research utilizing corporate funding.[1]

In mid-March, the U.S. Department of Commerce (DOC) announced in the Federal Register an antidumping duty order on ferrosilicon from Brazil. The DOC determined that ferrosilicon from Brazil is being, or is likely to be, sold in the United States at less than fair value. The U.S. International Trade Commission (ITC), which conducts its own investigation, determined that an industry in the United States is materially injured by reason of ferrosilicon imports from Brazil. The period of investigation was July 1, 1992 through December 31, 1992. The DOC directed the Customs Service to assess antidumping duties, margin amount, equal to the amount by which the foreign market value of the product exceeds the U.S. price. The duties were to be assessed on all unliquidated entries of fer-rosilicon from Brazil entered, or withdrawn from warehouse, for consumption on or after August 16, 1993. A duty of 3.46% exists for Companhia Ferroligas Minas Gerais, 88.86% for Italmagnesio S.A. Industria e Comercio, 15.53% for Companhia Brasileira Carbureto de Calcio, and 35.95% for all others, effective March 14, 1994.

The Brazilian investigation was the culmination of a series of antidumping and countervailing duty cases initiated in response to a petition filed in May 1992. Prior to the decision on Brazil, the DOC assessed dumping duties for China at 137.73%; Kazakhstan, Russia, and Ukraine at 104.18%; and Venezuela at 9.55%. Venezuela also was assessed a countervailing duty of 22.08%. However, in the cases of Argentina and Egypt, it was determined that an industry in the United States is not materially injured or threatened with material injury by reason of ferrosilicon from the two countries.

The DOC and ITC investigations were instituted in response to petitions filed by Applied Industrial Minerals Corp., Alabama Silicon Inc., American Alloys, Globe Metallurgical Inc., Silicon Metaltech Inc. (American Silicon Technologies), and union locals of the United Autoworkers of America, the United Steelworkers of America, and the Oil, Chemical & Atomic Workers.

DOC's administration review of the countervailing duty order on ferrosilicon from Venezuela was terminated in mid-December, with no changes being made to the initial duty order.

In early-April, the DOC announced in the Federal Register an amendment to its December 1993 final results of the administrative review of the antidumping duty order on silicon metal from Argentina. Owing to a clerical error, the dumping margin for Silarsa S.A. was lowered to 24.62% from 54.67%. Final dumping margins of 2.06% for Electrometalurgica S.A.I.C. (Andina) and 8.65% for "all others" remained unaffected by the amendment.

In August, the DOC also announced in the Federal Register final results of its administrative review of the antidumping duty order on silicon metal from Brazil. DOC's review of Brazil covered four manufacturers/exporters: Companhia Brasileira Carbureto de Calcio, Companhia Ferroligas Minas Gerais, Eletrosilex Belo Horizonte, and Rima Electrometalurgia S.A. (RIMA). As a result of its review, DOC determined that a margin of 91.06% existed for RIMA for the period March 29, 1991 through June 30, 1992.

On December 8, 1994, the President of the United States signed legislation adopting the Uruguay Round accords of the General Agreements on Tariffs and Trade (GATT) which included renewal of the GSP program until July 31, 1995. The GSP program had expired on September 30, 1994. The legislation extending the GSP was retroactive to September 30. Under GSP, the United States grants duty-free access to goods from more than 140 developing countries and territories. In 1994, U.S. import duties for selected silicon materials ranged from duty free to 9% ad valorem for most-favored-nation (MFN) status and from $0.044 per kilogram of contained silicon to 45% ad valorem for non-MFN status.

In Proclamation 6650 of February 16, 1994, the President of the United States designated Kazakhstan and Romania as beneficiary developing countries for purposes of the GSP, effective March 4, 1994. In Proclamation 6655 of March 3, 1994, the President also granted GSP status to Ukraine, effective March 23, 1994. The extension of GSP status is part of the Administration's overall effort to facilitate Kazakhstan, Romania, and Ukraine's transformation to free market economies. Additionally, GSP status was granted to the Republic of South Africa in Proclamation 6676 of April 21, 1994, effective May 10, 1994.

Production

Overall gross production of silicon products in the United States decreased 7% compared with that of 1993. Production of silicon metal was down slightly, while production of ferrosilicon and miscellaneous alloys was up by about 11%. Overall shipments of silicon-containing products increased by 2%. Producer stocks of silicon-containing materials were down by about 9% overall. Ferrous scrap used in the production of these products was estimated to be about 150,000 tons. Domestic production data for the silicon commodity are developed by the U.S. Bureau of Mines by means of monthly and annual voluntary surveys, and Bureau estimates. The "Silicon Alloys" survey canvasses the operations listed in table 3. The figures in table 2 represent 100% of the production and shipments from these operations. *(See tables 1, 2, and 3.)*

Production of silicon metal and silicon alloys is extremely power intensive, requiring a power input, for some operations, of up to 14,000 kilowatt-hours per ton of silicon content.

The location of ferrosilicon and silicon metal smelters is normally determined by balancing marketing costs against processing costs. Principal elements in the cost of silicon and ferrosilicon production are (1) delivered costs of the ore; (2) energy cost; (3) cost of reductant coke or low ash coal; (4) cost of iron in the form of steel scrap, if required; and (5) labor. The cost of all these elements, and particularly the cost of energy, has increased rapidly since 1970. In addition, new capital costs for pollution control equipment were added.

Recovery of silicon from secondary sources is not normally practiced. The only secondary possibility is recovery from scrap metal. However, any value of contained silicon would be incidental to the value of the primary metal. In 1994, the average price for ferrosilicon was about $0.42 per pound and the average price for silicon metal was about $0.64 per pound. For the future, recycling of silicon in the form of ferrosilicon and silicon metal is expected to be insignificant.

In early February, Elkem Metals Company announced that it had decided to temporarily shut down production of the 50-megawatt ferrosilicon furnace at its plant in Ashtabula, OH. The shutdown would occur about April 15, resulting in the layoff of about 200 of the plant's 300 employees. The shutdown was prompted by noncompetitive power costs and high labor requirements to operate an aging facility. Production would resume when economic factors improve enough to allow the company to operate the furnace profitably. Elkem will continue to supply its North American customers with ferrosilicon products from the company's Canadian and Norwegian production facilities.[2] The furnace at Ashtabula produces about 60,000 tons per year of 50%-grade ferrosilicon and related products for use in the steel and foundry industries.[3]

In late December, Globe Metallurgical Inc., Cleveland, OH, announced the purchase of SKW Metals & Alloys Inc.'s Niagara Falls, NY, silicon manufacturing facility. Financial details of the acquisition were not disclosed. The facility, built in 1913, reportedly is the oldest operating ferroalloys plant in the United States. The facility houses two 36-megavolt-ampere electric furnaces. One built in 1976 produces ferrosilicon and the other built in 1987 produces silicon metal.[4] Globe, a producer and worldwide distributor of foundry alloys and silicon metal, has additional U.S. silicon production facilities in Beverly, OH; Selma, AL; and Springfield, OR. SKW will continue to produce ferroalloys at its facilities in Calvert City, KY; Quebec, Canada; and Germany.

In November, it was reported that Dow Corning Corp., Midland, MI, planned to move ahead to the commercialization phase of the company's direct current closed-furnace silicon metal manufacturing technology development program. The company was seeking partners to commercialize the technology, with plans for having a facility on-line by 1997. Dow reported that testing at its pilot plant in Selkirk, Manitoba, Canada, showed that the technology is more energy efficient, environmentally friendly, and safer to operate than current open-furnace processes. The plant, commissioned in 1992, was scheduled to be shut down at the end of November 1994. Funding for the pilot plant was provided by Dow, about $20 million; Western Economic Development Canada, $5 million; the Province of Manitoba, $5 million; and the U.S. Department of Energy, $2 million.[5]

Consumption

The aluminum industry used silicon metal in the production of wrought and cast products, while ferrosilicon was used primarily as a deoxidizing and alloying agent in the production of iron and steel products. Metallurgical-grade silicon metal also was used as the basic raw material in the manufacturing of many chemical products and intermediates such as silicones and silanes. Overall reported consumption of silicon alloys and metal increased slightly from that of 1993. *(See table 4.)*

U.S. apparent consumption of silicon metal and silicon-containing ferroalloys was estimated to be about 607,000 tons of contained silicon. Consumption of silicon metal was estimated at about 247,000 tons, while consumption of ferrosilicon and miscellaneous silicon alloys was estimated to be about 360,000 tons. Compared with that of 1993, consumption of silicon metal increased by about 10%, while consumption of ferrosilicon and other alloys increased by about 7%. Ferrosilicon and miscellaneous silicon alloys accounted for about 60% of all the silicon materials consumed, based on silicon content.

Prices

Demand for metallurgical-grade silicon alloys and metal is determined by the level of activity in the steel, ferrous foundry, aluminum, and chemical industries and is little affected in the short term by prices for these materials. As a result, prices tend to vary widely with changes in demand and supply.

The Metals Week "dealer import" price, posted in cents per pound of contained silicon, for 50%- and 75%-grade ferrosilicon was in decline for most of the year. However, the average annual price for the materials increased from that of 1993. *(See table 1.)* The import price for 50%-grade ferrosilicon started the year at a range of $0.44 to $0.45 per pound, fell to a range of $0.425 to $0.435 through mid-December, then rose to finish the year at $0.435 to $0.445. The import price for 75%-grade ferrosilicon decreased progressively from a range of $0.435 to $0.445 per pound to $0.40 to $0.41 through November, then increased to $0.410 to $0.425 by yearend.

The Metals Week "dealer import" price, posted in cents per pound of contained silicon, for silicon metal increased during the year, but the average annual price for the material decreased from that of 1993. *(See table 1.)* The import price for silicon metal rose from a range of $0.59 to $0.62 per pound to $0.65 to $0.67 by midyear, where it remained through December.

Foreign Trade

U.S. exports of ferrosilicon decreased by about 4% compared with that of 1993, based on gross weight, while total value of the exports was down slightly. *(See table 5.)* Almost 50% of the exported material was shipped to Canada. Silicon metal exports increased by about 14% based on gross weight, with total value of the exports up by about 5%. Canada, Japan, and Mexico were major recipients of the materials, with almost 70% of the total.

U.S. imports of silicon-containing alloys were up by 2% compared with that of 1993. *(See table 6.)* Total value of the exports were up by about 13%. Imports of ferrosilicon categorized as "55% to 80% silicon, other" increased by about 5% based on gross weight, with the total value for this category increasing by more than 10%. Brazil, Ireland, and Norway were the leading suppliers for this category, with about 65% of the total. Imports of ferrosilicon categorized as "Other," which included all ferrosilicon of less than 55% silicon content, continued to decline. Norway accounted for over 30% of total ferrosilicon imports.

Overall imports of silicon metal products increased by almost 40%, with total value of imports up by about 20%. Imports of silicon metal categorized as "99.00% to 99.99% silicon" increased by about 35%, with Canada providing over 40% of both total volume and value. Imports of "Other" silicon metal increased by about 40%, with Russia supplying about 80% of both volume and value for this category.

The schedule of applied tariffs during 1994 to U.S. imports of selected silicon materials can be found in the U.S. International Trade Commission's (USITC's) 1994 Harmonized Tariff Schedule of the United States, USITC Publication 2690.

The U.S. net import reliances for ferrosilicon and silicon metal products were estimated to be 36% and 35%, respectively, compared with 38% and 28% the previous year. The overall import reliance for silicon products was estimated to be 36%.

World Review

Bhutan.—In mid-March, it was reported that Bhutan Farewells Ltd. would commence ferrosilicon production at its new plant being constructed by Elam Metals Co. Production from the plant is planned at about 15,000 tons per year. One-half of the plant's production reportedly will be exported to Japan, and the remaining production will be sold in India.

Brazil.—In August, it was reported that a new company, Silicio de Alta Pureza de Bihia (SILBASA), had been formed to produce ferrosilicon in Brazil. The new company is a joint venture between Brazil's Cia. De Ferro-Ligas da Bahia SA (Ferbasa), 51% share, and Japan's Japan Metals & Chemicals Co. Ltd. and Marubeni Corp., both companies with 24.5% shares. The SILBASA plant will have an annual capacity to produce about 14,000 tons of "special high-grade ferrosilicon" for possible use in the production of electrical sheet steel. Details on material specification were not disclosed. Ferbasa will provide the plant with ferrosilicon for conversion to the high-grade material. Plant output is planned at 8,000 tons in 1995, 10,000 tons in 1996, and 14,000 tons in 1997.[6]

Ligas de Aluminio SA (Liasa), a major Brazilian silicon metal producer, reportedly recovered from bankruptcy status by making final payment, $14 million, to its creditors. Liasa had sought protection from its creditors under the Brazilian bankruptcy law in 1992. Liasa reportedly produces about 38,000 tons of silicon metal per year.[7]

Late in the year, ferrosilicon and silicon metal production were being affected in the Minas Gerais State by a severe drought and resulting increased cost of electric supply. Around November, Nova Era Silicon, formerly Eletrovale SA Industria e Comercio, and Cia. Brasileira Carbureto de Calcio each shut down a 30,000 kilowatt ferrosilicon furnace. Silicon metal producers Liasa and Rima Electrometalurgia SA were also said to be affected by the drought/expensive power supply.

China.—According to The TEX Report, production of ferrosilicon in China in 1993 totaled 760,000 tons and Chinese consumption of ferrosilicon totaled 440,000 tons. In the year 2000, Chinese ferrosilicon production was expected to be 875,000 tons with domestic consumption at 575,000 tons.[8] The TEX Report also reported that Chinese exports of ferrosilicon in 1994 totaled about 300,000 tons valued at about $148 million, compared with 340,000 tons valued at $157 million the previous year.

Germany.—Huls AG, Marl, reportedly will spend about $173 million to expand silicone production at Nunchritz, its affiliate in eastern Germany. The expansion at Nunchritz will raise annual siloxanes capacity from 12,000 tons to 60,000 tons by the end of the decade.[9] Bayer AG plans to double production of silicone products at its facility in Leverkusen. Bayer will expand annual capacity on a "step-by-step" basis to about 150,000 tons of crude silanes, the base product for silicones.[10]

India.—The Kerala State in southern India has been the beneficiary of new ferrosilicon production facilities due to the lower cost of electric power. The region's two new plants, Silcal Metallurgic Ltd. and Indsil Electrosmelt Ltd., along with the Travancore Electro-Chemical Industries Ltd. plant, account for about 30,000 tons of annual ferrosilicon production capacity. India has an overall ferrosilicon production capacity of about 150,000 tons.[11] In March, it was reported that changes as presented in India's annual budget would lower the import duty on bulk alloys and silicon metal from 85% to 50%. The lower duties, with a potential increase in imports, were seen locally as possibly leading to curtailment of some production capacity for power intensive products such as ferrosilicon and silicon metal.[12]

Iran.—In March 1995, the Iran Ferrosilice Co. reportedly will commence operation of its new 25,000-ton-per-year ferrosilicon plant, Semnan, Iran. The plant will produce 75%-grade ferrosilicon for domestic sale and for export to Europe. The supplier of the equipment for the plant was the German firm Mannesmann Demag Huttentechnik.[13]

Japan.—Japan's production of ferrosilicon was about 13,100 tons, compared with about 29,100 tons in 1993. According to The TEX Report, imports of ferrosilicon by Japan totaled about 484,000 tons, compared with about 542,000 tons the previous year. China continued as the leading supplier accounting for about 238,000 tons of the imports, a 50% increase from that in 1990. Imports of silicon metal by Japan were virtually unchanged at about 152,000 tons. Silicon metal imports from China and Brazil totaled about 83,800 tons and 39,300 tons, respectively. Consumption of silicon metal by the Japanese aluminum alloy sector rose to about 54,000 tons from the 51,000 tons in 1993, influenced by a 3% increase in the production of secondary aluminum alloys.

Kazakhstan.—In May, it was reported that ferrosilicon production at the Yermakovsky Ferroalloy Works (Ermak) was about 450,000 tons. However, with antidumping duties imposed on ferrosilicon from Kazakhstan in the United States and the European Union, Ermak indicated plans to convert some ferrosilicon production capacity to the production of ferrochromium. The conversion project would be undertaken within 3 to 4 years.[14]

Saudi Arabia.—During the year, the Gulf Ferroalloys Co. reportedly commenced construction of its ferroalloy plant at Jubail, Saudi Arabia. The partnership of Germany's Mannesmann Demag Huttentechnik and BHP Engineering of Australia was awarded the contract to build the plant. The plant will cost in excess of $100 million to construct and is expected to be on-line by yearend 1996. When fully operational, the plant will have an annual capacity to produce 35,600 tons of ferrosilicon, 10,000 tons of silicon metal, 27,600 tons of silicomanganese, and 10,000 tons of ferromanganese.[15]

South Africa, Republic of.—In June, Silicon Technology Pty. Ltd. (Silitech), a subsidiary of Chromecorp Technology Pty. Ltd., temporarily shut down its ferrosilicon plant in Natal, South Africa. The plant commenced operation at the end of 1992, and the closure reportedly resulted from poor market conditions, antidumping duties imposed by the European Commission, technical problems experienced by the electric furnaces, and a labor strike. The plant will remain closed until yearend, at which time Silitech will make a decision to restart production on a smaller scale or possibly produce another product.[16] The plant comprises two electric furnaces, a 40-megavolt-ampere (M•VA) furnace and a 56-M•VA furnace, with a combined annual ferrosilicon production capacity of about 55,000 tons.

Venezuela.—It was reported in September that State-owned ferrosilicon producer CVG Fesilven CA was preparing for privatization by public auction at yearend. The company had received the Venezuela government's approval for a project allowing Fesilven to form a joint venture with a "majority private sector partner." Fesilven's plant production of 75%-grade ferrosilicon in 1994 was expected to be about 60,000 tons, with planned production in 1995 at about 80,000 tons.[17]

Outlook

Demand for silicon metal continues to be driven by consumption in the aluminum and chemical industries. For 1995, industry sources indicate that Western World silicon metal demand will be about 715,000 tons. In the aluminum industry, silicon metal demand is expected to be about 405,000 tons, influenced by the automotive sector, with demand in the chemical industry at about 310,000 tons. By the year 2000, overall silicon metal demand is expected to be more than 900,000 tons. European and North American silicon metal demand in the chemical and metallurgical sectors is strong. However, silicon metal demand in Japan remains flat, owing to a recessed economy and declining automotive sales.[18] Within the chemical industry, silicon metal is used to produce a wide variety of silicone-base products and intermediates. Industry sources, as reported in Chemical Week, indicate that the domestic silicon compounds industry will grow by more than 5% per year through 1997. Silicon growth in this sector is attributed to silicone elastomers (particularly injection-moldable silicone rubbers), silicon alloys used in superalloy production, and silicones used in household and personal care products, all of which are expected to increase about 7% per year during this period.

Ferrosilicon is consumed primarily by the iron and steel industry. The industry uses ferrosilicon for deoxidation of molten metal and as an alloying agent. The reader is referred to the outlook section of the Iron and Steel Annual MIS for discussion on the outlook for the steel industry. Additionally, Metal Bulletin reported that some leading industry sources anticipate that western world steel production and consumption will increase through the year 2000. However, steel demand in countries of the former U.S.S.R. will continue to decline owing to economic problems in those countries. Also, an excellent analysis of future production trends in the ferrosilicon industry was presented by Resource Strategies Inc. at Metal Bulletin's 10th International Ferroalloys Conference in Barcelona, Spain, November 7, 1994.

For 1995, it is estimated that domestic production of silicon-containing ferroalloys and metal will be about 400,000 tons, and U.S. apparent consumption will be about 600,000 tons.

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[1] The Washington Post. No. 304, Oct. 5, 1994, p. F2.

[2] Elkem Metals Company. News Release, Feb. 1995, 3 pp.

[3] American Metal Market. V. 102, No. 14, Jan. 21, 1994, p. 16.

[4] Globe Metallurgical Inc. News Release, Dec. 30, 1994, 1 p.

[5] Chemical and Engineering News. V. 72, No. 46, Nov. 14, 1994, pp. 11-12.

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[6] Metals Week. V. 65, No. 35, Aug. 29, 1994, p. 3.

[7] American Metal Market. V. 102, No. 105, June 2, 1994, p. 5.

[8] The TEX Report. V. 26, No. 6212, Oct. 5, 1994, pp. 5-6.

[9] European Chemical News. V. 62, No. 1633, Sept. 5, 1994, p. 4.

[10] Chemical Week. V. 155, No. 24, Dec. 21-28, 1994, p. 14.

[11] Metal Bulletin Monthly. No. 282, July 1994, pp. 54-57.

[12] Metal Bulletin. No. 7861, Mar. 7, 1994, p. 13.

[13] ———. No. 7928, Nov. 7, 1994, p. 15.

[14] The TEX Report. V. 26, No. 6121, May 25, 1994, p. 1.

[15] Metal Bulletin. No. 7870, Apr. 11, 1994, p. 13.

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[16] Metal Bulletin. No. 7922, Oct. 17, 1994, p. 10.

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[17] Metal Bulletin. No. 7910, Sept. 5, 1994, p. 13.

[18] The TEX Report. V. 26, No. 6147, June 30, 1994, pp. 4-5.

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TABLE 1
SALIENT SILICON STATISTICS 1/

(Thousand metric tons of silicon content unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production	418	363	370	367	390
Exports:					
Ferrosilicon	27	27	30	21	20
Silicon metal	9	8	8	10	12
Imports for consumption:					
Ferrosilicon	152	121	161	141	147
Silicon metal	66	43	32	71	108
Apparent consumption:					
Ferrosilicon	390	325	337	335	360
Silicon metal	198	175	195	222	247
Price; average per pound Si: 2/					
Ferrosilicon, 50% Si	42.44	38.34	36.94	40.76	43.93
Ferrosilicon, 75% Si	39.94	36.98	35.41	40.61	40.77
Silicon metal	54.84	61.50	59.95	66.40	64.13
World production (gross weight): e/					
Ferrosilicon	4,800	4,300	4,100	4,200	4,100
Silicon metal	630	590	560	550	540

e/ Estimated.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Platt's Metals Week dealer import price.

TABLE 2
PRODUCTION, SHIPMENTS, AND STOCKS OF SILVERY PIG IRON, FERROSILICON, AND SILICON METAL IN THE UNITED STATES IN 1994 1/

(Metric tons, gross weight, unless otherwise specified)

Material	Silicon content (percentage)		Producers' stocks, Dec. 31, 1993	Gross production 2/	Net shipments	Producers' stocks, Dec. 31, 1994
	Range	Typical				
Silvery pig iron	5 - 24	18	W	W	W	W
Ferrosilicon	25 - 55	48	43,900	198,000	136,000	35,400
Do.	56 - 95	76	17,100	112,000	111,000	20,100
Silicon metal (excluding semiconductor grades)	96 - 99	98	6,630	164,000	163,000	6,360
Miscellaneous silicon alloys (excluding silicomanganese)	32 - 65	--	14,700	103,000	95,700	13,400

W Withheld to avoid disclosing company proprietary data.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits.

2/ Ferrosilicon production includes material consumed in the production of miscellaneous silicon alloys.

TABLE 3
PRODUCERS OF SILICON ALLOYS AND/OR SILICON METAL IN THE UNITED STATES IN 1994

Producer	Plant location	Product 1/
American Alloys Inc.	New Haven, WV	FeSi and Si.
American Silicon Technologies	Rock Island, WA	Si.
Applied Industrial Minerals Corp.	Bridgeport, AL	FeSi.
Elkem Metals Co.	Alloy, WV	Si.
Do. 2/	Ashtabula, OH	FeSi.
Globe Metallurgical Inc.	Beverly, OH	FeSi and Si.
Do. 3/	Niagara Falls, NY	FeSi and Si.
Do.	Selma, AL	Si.
Do.	Springfield, OR	Si.
Keokuk Ferro-Sil Inc.	Keokuk, IA	FeSi and silvery pig iron.
Simetco Inc.	Montgomery, AL	Si.
SKW Metals and Alloys Inc.	Calvert City, KY	FeSi.

1/ FeSi, ferrosilicon; Si, silicon metal.

2/ Production closed down in April 1994.

3/ Formerly SKW Metals and Alloys Inc, Dec. 29, 1994.

TABLE 4
REPORTED CONSUMPTION, BY MAJOR END USE, AND STOCKS OF SILICON ALLOYS AND METAL IN THE UNITED STATES IN 1994 1/ 2/

(Metric tons, gross weight, unless otherwise specified)

Silicon content (percent)	Silvery pig iron	Ferrosilicon 3/				Silicon metal	Miscellaneous silicon alloys 4/	Silicon carbide 5/
Range	5-24	25-55	56-70	71-80	81-95	96-99	--	63-70
Typical	18	48	65	76	85	98	48	64
End use								
Steel:								
Carbon	--	32,800	(6/)	27,700	(6/)	(6/)	(6/)	(6/)
Stainless and heat-resisting	--	23,700	(6/)	42,100	(6/)	(6/)	(6/)	--
Other alloy	(6/)	20,300	--	31,700	(6/)	(6/)	(6/)	(6/)
Tool	--	(6/)	--	2,490	(6/)	--	--	--
Unspecified	22	49	59	--	632	12,400	2,110	90
Total	22	76,800	59	104,000	632	12,400	2,110	90
Cast irons	20,800	115,000	2,100	21,300	495	W	22,700	37,300
Superalloys	--	W	--	W	18	W	--	--
Alloys (excluding superalloy and alloy steel)	W	W	--	W	--	W	--	--
Miscellaneous and unspecified	11	1,460	--	948	--	205,000 7/	--	--
Grand total	20,800	194,000	2,160	126,000	1,150	217,000	24,800	37,400
Consumers' stocks, December 31	836	6,720	188	8,970	54	2,030	1,240	1,210

W Withheld to avoid disclosing company proprietary data, included with "Miscellaneous and unspecified."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes U.S. Bureau of Mines estimates.

3/ Includes briquets.

4/ Primarily magnesium - ferrosilicon but also includes other silicon alloys.

5/ Does not include silicon carbide for abrasive or refractory uses.

6/ Included with "Steel: Unspecified."

7/ Includes silicones, silanes, fumed silica, and other chemicals.

TABLE 5
U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY 1/

(Metric tons)

Country	1993			1994		
	Gross weight	Contained weight	Value	Gross weight	Contained weight	Value
Ferrosilicon:						
Over 55% silicon:						
Australia	160	96	$250,000	285	171	$414,000
Canada	6,300	3,780	5,090,000	4,410	2,650	3,560,000
Germany	433	260	609,000	156	96	255,000
Honduras	20	12	10,000	18	11	14,600
India	45	27	38,200	96	58	127,000
Japan	127	76	127,000	319	192	407,000
Korea, Republic of	25	15	24,100	36	22	31,600
Malaysia	--	--	--	50	33	86,600
Mexico	3,490	2,190	2,900,000	1,850	1,130	1,780,000
Taiwan	204	122	215,000	670	402	710,000
Other	192 r/	124 r/	217,000 r/	50	30	53,700
Total	11,000	6,710	9,470,000	7,940	4,790	7,430,000
Other ferrosilicon:						
Australia	970	483	1,150,000	1,300	650	1,490,000
Canada	15,900	7,940	11,600,000	13,900	6,950	10,000,000
Egypt	839	420	749,000	292	146	237,000
India	264	131	375,000	546	273	764,000
Japan	2,640	1,300	6,090,000	3,030	1,500	6,350,000
Korea, Republic of	1,380	687	1,320,000	1,830	912	1,500,000
Mexico	1,840	919	1,520,000	1,940	971	1,680,000
Spain	151	76	119,000	351	175	283,000
Thailand	57	28	66,500	295	147	438,000
United Kingdom	3,030	1,510	2,760,000	5,500	2,750	5,090,000
Other	1,470 r/	707 r/	1,550,000 r/	1,050	524	1,050,000
Total	28,500	14,200	27,300,000	30,000	15,000	28,900,000
Total ferrosilicon	39,500	20,900	36,800,000	38,000	19,800	36,300,000
Metal:						
Over 99.99% silicon:						
Czech Republic	1	1	61,200	32	32	1,430,000
Denmark	22	22	1,630,000	25	25	2,030,000
Finland	5	5	145,000	30	30	912,000
Germany	7	7	470,000	66	66	2,630,000
Italy	118	118	5,190,000	75	75	3,440,000
Japan	1,490	1,490	68,400,000	1,370	1,370	66,400,000
Korea, Republic of	201	201	9,430,000	170	170	7,620,000
Malaysia	161	161	30,300,000	145	145	34,600,000
Netherlands	17	17	795,000	23	23	1,600,000
Taiwan	11	11	560,000	38	38	1,080,000
Other	72 r/	72 r/	3,340,000 r/	104	104	4,960,000
Total	2,110	2,110	120,000,000	2,080	2,080	127,000,000
99.00 - 99.99% silicon:						
Australia	--	--	--	112 2/	94	53,200
Canada	19	19	26,100	10	10	12,700
Colombia	29	28	63,900	24	24	40,100
Ghana	--	--	--	56 3/	56	86,100
Israel	--	--	--	385	382	607,000
Mexico	157	156	213,000	38	38	53,600
Peru	--	--	--	9	9	14,000
Singapore	--	--	--	11	11	12,100
United Kingdom	318	315	446,000	9	9	13,300
Venezuela	452	448	707,000	104	103	154,000
Other	142 r/	139 r/	260,000 r/	37	36	62,800
Total	1,120	1,110	1,720,000	796	773	1,110,000
Other silicon:						
Canada	1,920	1,860	2,080,000	2,640	2,560	2,790,000
China	99	94	259,000	118	115	156,000
Germany	277	256	475,000	376	365	523,000
Italy	31	30	40,600	321	312	423,000
Japan	1,610	1,560	3,670,000	681	662	1,890,000
Korea, Republic of	145	141	206,000	342	332	498,000
Mexico	1,910	1,860	2,550,000	3,370	3,270	4,450,000
Taiwan	307	298	420,000	447	434	590,000
Trinidad and Tobago	--	--	--	101	96	59,800
United Kingdom	93	91	124,000	143	139	189,000
Other	999 r/	958 r/	1,480,000 r/	705	684	1,070,000
Total	7,400	7,140	11,300,000	9,240	8,970	12,600,000
Total silicon metal	10,600	10,400	133,000,000	12,100	11,800	140,000,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Contains 16 tons of material with silicon content not yet verified.

3/ Silicon content of material not yet verified.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL , BY GRADE AND COUNTRY 1/

(Metric tons)

Country	1993			1994		
	Gross weight	Contained weight	Value	Gross weight	Contained weight	Value
Ferrosilicon:						
55 - 80% silicon, over 3% Ca:						
Argentina	100	61	$86,900	--	--	--
Brazil	84	54	125,000	93	60	$93,100
Canada	--	--	--	75	45	16,600
China	172	103	155,000	--	--	--
France	62	38	94,700	80	48	100,000
Germany	4	3	8,600	1	1	3,650
Macedonia	--	--	--	1,500	1,120	976,000
Norway	184	139	216,000	--	--	--
Taiwan	51	36	45,000	--	--	--
United Kingdom	--	--	--	444	333	366,000
Total	657	434	731,000	2,190	1,610	1,550,000
55 - 80% silicon, other:						
Brazil	43,600	33,000	23,200,000	22,700	17,100	13,500,000
Canada	13,900	10,300	9,560,000	9,790	7,430	6,680,000
Iceland	13,100	9,980	7,350,000	29,300	22,500	16,800,000
Macedonia	3,110	2,330	1,720,000	7,600	5,730	4,260,000
Norway	66,200	50,100	39,600,000	66,700	50,500	41,600,000
Poland	9,380	6,980	5,290,000	6,930	5,170	3,890,000
Romania	--	--	--	4,500	3,380	2,680,000
Slovakia	--	--	--	9,980	7,550	6,400,000
South Africa, Republic of	3,810	2,860	2,170,000	6,920	5,220	4,000,000
United Kingdom	2,880	2,170	2,050,000	6,560	4,920	4,460,000
Other	15,300 r/	11,100 r/	9,220,000 r/	8,630	6,430	6,590,000
Total	171,000	129,000	100,000,000	180,000	136,000	111,000,000
80 - 90% ferrosilicon:						
Turkey	18	15	6,220	--	--	--
Over 90% ferrosilicon:						
Australia	320	317	430,000	--	--	--
Brazil	238	224	169,000	--	--	--
Total	558	540	599,000	--	--	--
Magnesium ferrosilicon:						
Brazil	1,740	789	1,060,000	3,120	1,440	2,150,000
Canada	35	17	18,400	336	165	228,000
Germany	776	423	2,590,000	614	332	2,020,000
India	--	--	--	43	20	44,600
Japan	79	37	169,000	62	27	135,000
Norway	--	--	--	2,560	1,080	2,090,000
Total	2,630	1,270	3,840,000	6,740	3,060	6,670,000
Other ferrosilicon:						
Belgium	3	1	8,710	--	--	--
Brazil	9,910	4,190	1,020,000	--	--	--
Canada	10,400	3,690	3,140,000	15,300	5,790	5,560,000
China	34	13	51,800	--	--	--
France	5	3	13,200	--	--	--
Kazakhstan	--	--	--	410 2/	115	205,000
Venezuela	4,500	2,430	948,000	--	--	--
Total	24,900	10,300	5,190,000	15,700	5,900	5,760,000
Total ferrosilicon	200,000	141,000	111,000,000	204,000	147,000	125,000,000
Metal:						
Over 99.99% silicon:						
China	(3/)	(3/)	65,700	4	4	495,000
Czech Republic	2	2	414,000	4	4	765,000
France	2	2	140,000	(3/)	(3/)	119,000
Germany	483	483	14,100,000	463	463	14,300,000
Italy	268	268	28,700,000	223	223	20,200,000
Japan	84	84	2,410,000	250	250	6,440,000
Korea, Republic of	42	42	952,000	104	104	414,000
Taiwan	(3/)	(3/)	5,280	4	4	434,000
Ukraine	1	1	17,800	51	51	1,020,000
United Kingdom	1	1	35,600	20	20	167,000
Other	3 r/	3 r/	543,000 r/	1	1	238,000
Total	886	886	47,300,000	1,120	1,120	44,500,000
99.00 - 99.99% silicon:						
Australia	3,320	3,290	4,210,000	7,510 4/	7,400	9,370,000
Brazil	338	335	391,000	372	369	478,000
Canada	13,200	13,100	18,100,000	15,200	15,100	21,500,000
France	593	589	731,000	4,230	4,200	5,180,000
Germany	20	20	17,000	404	400	524,000
Netherlands	201	199	235,000	400	398	480,000
Norway	621	617	757,000	2,630	2,610	3,210,000
Russia	--	--	--	1,720	1,700	1,700,000
South Africa, Republic of	3,160	3,130	3,650,000	3,160	3,050	3,590,000
Spain	--	--	--	412	408	487,000
Other	5,650 r/	5,530 r/	6,890,000 r/	848	780	982,000
Total	27,100	26,800	35,000,000	36,900	36,400	47,500,000
Other silicon:						
Australia	201	198	246,000	120	60	136,000
Canada	879	864	1,110,000	1,970	1,920	2,500,000
China	2,470	2,560	2,210,000	1,380 5/	5,740	1,150,000
Germany	616	559	881,000	274	264	219,000
Japan	2	2	19,800	477	467	590,000
Macedonia	5,090	5,010	5,400,000	4,810	4,730	4,990,000
Netherlands	548	530	477,000	400 2/	(3/)	94,900
Russia	31,300	30,400	29,600,000	50,900 6/	55,400	48,100,000
South Africa, Republic of	901	887	1,010,000	342	338	358,000
Ukraine	1,920	1,860	1,910,000	1,250	1,210	1,190,000
Other	351 r/	335 r/	351,000 r/	453	444	503,000
Total	44,300	43,200	43,300,000	62,400	70,600	59,900,000
Total silicon metal	72,200	70,900	126,000,000	100,000	108,000	152,000,000

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Silicon content of material not yet verified.
3/ Less than ½ unit.
4/ Contains 440 tons of material with silicon content not yet verified.
5/ Contains 355 tons of material with silicon content not yet verified.
6/ Contains1,530 tons of material with silicon content not yet verified.
Source: Bureau of the Census.

SILVER

By Robert G. Reese Jr.

Domestic silver mine production declined for the fourth consecutive year, owing primarily to a decline in byproduct silver production. About 120 mines in 20 States produced silver during the year. Nevada, Arizona, and Idaho were the largest silver-producing States, accounting for nearly three-fourths of the production. The largest 13 mines each produced more than 30 tons of silver and accounted for more than 77% of the total domestic production. The value of domestic production was $252 million.

Commercial-grade silver is material that is at least 99.9% pure silver. In the United States, about 20 companies produced commercial-grade silver from either primary or recycled material. Although most of these companies were headquartered in the Northeast, many had collection sites or plants in locations throughout the country. Aiding the recycling of silver were many other companies. These companies, located throughout the country, collected the material for recycling, and some produced a semirefined product that could be converted to commercial-grade silver.

Many companies and probably thousands of artisans scattered throughout the country consumed silver in 1994. The 30 largest companies probably accounted for more than 90% of the silver consumed in arts and industry. About 50% of the commercial-grade silver consumed in the United States was used in the manufacture of photographic products; 20% in electrical and electronic products; 10% in electroplated ware, sterlingware, and jewelry; and 20% in other uses.

In World Silver Survey 1995, published by the Silver Institute, it was estimated that world fabrication demand for silver had decreased in 1994, owing primarily to a decline in demand in India and Thailand.[1] Total world fabrication demand, including China and the former Soviet Union, was put at about 23,300 tons in 1994, compared with nearly 23,700 tons in 1993.

Legislation and Government Programs

On September 29, the President signed Public Law 103-328, the Riegle-Neal Interstate Banking And Branching Efficiency Act of 1994. Section 204 of P.L. 103-328 authorized the minting of not more than 800,000 coins to commemorate the 1995 Special Olympics World Games. Added to the price of each coin was a $10 surcharge. Surcharge revenues were to go to the 1995 Special Olympics World Games Organizing Committee, Inc. to stage and promote the 1995 Special Olympics World Games.

Production

Silver was produced from precious-metal ores at 64 lode mines and from base metal ores at 44 lode mines. In 1994, 13 mines each produced more than 30 tons of silver; their aggregated production equaled 77% of total domestic production. Probably fewer than 10 placer operations recovered silver in 1994, and the quantity recovered was less than 1% of total domestic production.

Domestic mine production data for silver were developed by the U.S. Bureau of Mines from three separate, voluntary surveys of U.S. operations. Typical of these surveys was the lode mine production survey of copper, gold, lead, silver, and zinc. Of the 108 silver-producing lode mines to which a survey form was sent, 98 responded, accounting for an estimated 91% of the total U.S. mine production shown in tables 1 and 2.

Idaho.—In 1994, under its first full year of ownership by Kinross Gold Corp., the DeLamar Mine recorded the highest tonnage of ore mined and milled during its 18 years of operation. For the year, 1.2 millions tons of ore were mined. From the 1.1 millions tons of ore milled, workers at DeLamar produced about 1,121 kilograms (kg) of gold and nearly 53 tons of silver.[2]

Hecla Mining Co. began commercial production at the Grouse Creek Mine in December, utilizing both surface and underground mining methods. A 5,400-ton-per-day mill located onsite processed the ore to produce a gold-silver doré. Hecla shipped the doré to a commercial refiner for upgrading. In February 1994, Hecla had sold a 20% interest in the mine to Great Lakes Minerals Inc., a Canadian company. Hecla expected the mine to achieve full production during the second quarter of 1995. During December, Grouse Creek produced 81 kg of gold and 341 kg of silver.[3]

After nearly 55 years of operation, cumulative silver production at the Lucky Friday Mine reached 3,110 tons (100,000,000 troy ounces) in March. In late August, an accident damaged the mine's main hoisting shaft and headframe, necessitating closure of the mine. Following repair of the shaft and headframe, production resumed in early December. During 1994, Hecla milled more than 113,000 tons of ore and recovered 19 kg of gold, 12,000 tons of lead, nearly 41 tons of silver, and 2,200 tons of zinc.[4]

Production at the Sunshine Mine declined for the fourth consecutive year. Company officials attributed the continued decline to the corporate decision to produce exclusively from the central portion of the mine during the past 4 1/2 years. As a result, mining had begun to affect the accessibility of reserves in this area. The eastern portion of the Sunshine Mine was expected to remain closed until silver prices improved. For the year, the Sunshine Mine processed 97,000 tons of ore and recovered nearly 65 tons of silver, 327 tons of copper, and 215 tons of antimony.[5]

Montana.—Gold and silver production at the Beal Mountain Mine remained essentially unchanged. For 1994, company officials reported that the mine produced 1,904 kg of gold and 271 kg of silver.[6] Comparable data for 1993 were 1,844 kg of gold and 267 kg of silver.

At the Black Pine Mine, Pegasus Gold Corp. upgraded the solution distribution system and increased the tonnage mined in the fourth quarter in part to counteract the effects of mining lower grade ore during most of the year. For 1994, Pegasus mined

5.8 million tons of ore at Black Pine and recovered approximately 2 tons of gold and 1 ton of silver.[7]

At its Kendall Mine, Canyon Resources Corp. mined 1.4 million tons of ore and extracted about 1,500 kg of gold and 700 kg of silver during 1994.[8] Although the company finished mining at the site in January 1995, leaching was expected to continue over the next 2 to 3 years.

Despite a higher mill throughput, silver production at the Montana Tunnels Mine declined in 1994 owing in part to lower silver content of the ore. For the year, Montana Tunnels milled nearly 4.9 million tons of ore and recovered 2.5 tons of gold, nearly 34 tons of silver, 8,500 tons of lead, and 18,000 tons of zinc.[9] In 1994 the pit at Montana Tunnels reached its maximum extent, and future mining was expected to take place in the core of the pit.

Although gold production at the Zortman/Landusky Mine was essentially unchanged in 1994, silver production declined for the third consecutive year. Production for 1994 was 3.4 tons of gold and 14 tons of silver compared with 1993's production of 3.4 tons and nearly 17 tons of gold and silver respectively.[10] Among the more notable projects completed at Zortman/Landusky during the year were construction of a 2,500-gallon-per-minute Merrill Crowe plant and construction of a water treatment plant.

Nevada.—Heap leaching of ore from the Reona deposit at Battle Mountain Gold Corp.'s Battle Mountain complex began in the third quarter. However, owing primarily to the slow startup of the Reona heap-leach facility, total gold and silver production at the Battle Mountain complex declined in 1994. For the year, Battle Mountain added nearly 2.6 million tons to the leach pads, and recovered 1,493 kg of gold and nearly 3 tons of silver. For 1993, the complex produced 1,897 kg and more than 3.5 tons of gold and silver respectively.[11]

In its first full year of operation since 1990, the Candelaria Mine mined and processed 2.7 million tons of ore to produce nearly 100 tons of silver and 393 kg of gold.[12] During the year, work began on developing the Northern Belle deposit, which along with the Mount Diablo Pit are expected to be the major sources of ore in 1995. The Georgine Pit, a deposit mined previously, was fully reclaimed by September 1994.

At its Denton-Rawhide Mine Kinross mined 15.1 million tons, and produced 3.7 tons and more than 30 tons of gold and silver respectively.[13]

Production at the Florida Canyon Mine declined slightly owing in part to the higher clay content of the ore mined. Toward yearend, Pegasus increased leach solution application rates on the heap to speed up gold and silver recovery, but the results were not expected to be evident until 1995. For 1994, workers at Florida Canyon produced 2.9 tons of gold and 787 kg of silver.[14]

Silver production at the McCoy/Cove Mine decreased for the first time in 4 years, owing primarily to a decline in the quantity of silver recovered by heap leaching. Heap leaching is most economical for processing lower-grade oxide ore. With the depletion of most of McCoy/Cove's oxide ore during the first quarter, output depended on processing sulfide ore using the mine's 6,800-ton-per-day mill. For 1994, the mine heap leached 7.2 million tons of ore and recovered 2,072 kg of gold and 29,258 kg of silver. Milling 6.6 million tons of ore produced an additional 9,105 kg of gold and 295,561 kg of silver.[15] Corresponding data for 1993 were heap leaching, 8.1 million tons yielding 3,115 kg and 74,864 kg of gold and silver respectively, and milling of 7 million tons yielding 9,190 kg of gold and nearly 313 tons of silver.

Residual gold and silver recovery continued at the depleted Paradise Peak Mine. According to FMC Gold, continued heap leaching recovered about 1,200 kg of gold and 4 tons of silver.[16] Ongoing reclamation of the mine site was expected to continue into 1997.

Coeur d'Alene Mines Corp. completed construction of a new leach pad and a conveyor system at its Rochester Mine in September. The new conveyor, which transports ore over 1.5 kilometers to the new pad, lowers the mine's operating costs by eliminating the need to truck ore to the pad. Gold and silver production at Rochester remained essentially unchanged from the previous year. In 1994, workers at Rochester mined over 7.1 million tons of ore, and produced nearly 2 tons of gold and 185 tons of silver.[17]

Other States.—At the San Luis Mine in Colorado, Battle Mountain reported the production of 2,271 kg of gold and 591 kg of silver, about the same as in 1993.[18]

In October, Hecla announced that it would close its Republic Mine in northeast Washington following depletion of known reserves. For the year, the Republic Mine processed 109,000 tons of ore, and recovered more than 1 ton of gold, and nearly 9 tons of silver.[19] Although Hecla's exploration for additional reserves over the past 5 years had proved unsuccessful, the company was considering additional exploration activities at the mine during 1995. At yearend 1994, the Republic Mine employed 85 people.

Outlook

Byproduct silver from the processing of other nonferrous metals such as copper, gold, lead, and zinc, remains the dominant component of domestic and world silver supply. As a result, the quantity of silver produced, is in many instances, more dependent on the price of the primary metal than on the price of silver. Although domestic production will continue to respond to price movements for other nonferrous metals, it is believed that domestic production of silver will increase slightly in the near term, but remain in the range of 1,400 to 2,000 tons. Worldwide, mine production of silver should remain at about 15,000 tons.

During the next few years, the domestic demand for silver will likely follow the general economy, either upward or downward, but remain at approximately 3,700 tons. Similarly, local economic conditions are expected to be the major determinate of silver demand in other countries, although demand could increase slightly as new markets in less-developed countries are gradually developed.

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[1] The Silver Institute. World Silver Survey 1995, 64 pp; available upon request from the Silver Institute, 1112 16th St., NW, Suite 2401, Washington, DC 20036.

[2] Kinross Gold Corp. 1994 Annual Report, 58 pp.

[3] Hecla Mining Co. 1994 10K Report, 95 pp.

[4] Work cited in footnote 3.

[5] Sunshine Mining Co. 1994 Annual Report, 25 pp.

[6] Pegasus Gold Inc. 1994 Annual Report, 54 pp.

[7] Work cited in footnote 6.

[8] Canyon Resources Corp. 1994 Annual Report, 56 pp.

[9] Work cited in footnote 6.

[10] Work cited in footnote 6.

[11] Battle Mountain Gold Co. 1994 Annual Report, 64 pp.

[12] Work cited in footnote 2.

[13] Work cited in footnote 2.

[14] Work cited in footnote 6.

[15] Echo Bay Mines Ltd. 1994 10K Report, 112 pp.

[16] FMC Gold Co. 1994 Annual Report, 24 pp.

[17] Coeur d'Alene Mines Corp. 1994 Annual Report, 60 pp.

[18] Work cited in Footnote 11.

[19] Work cited in Footnote 3.

TABLE 1
SALIENT SILVER STATISTICS 1/

		1990	1991	1992	1993	1994
United States:						
Mine production	metric tons	2,120	1,860	1,800	1,640 r/	1,480
Value	thousands	$329,000	$241,000	$229,000	$227,000	$252,000
Refinery production:						
Domestic and foreign ores and concentrates	metric tons	1,940	1,880	2,160	1,790 r/	1,810
Scrap (old and new) 2/	do.	1,680	1,700	1,760	2,020	1,700
Exports:						
Refined	do.	736	787	911	705	868
Imports for consumption:						
Refined	do.	2,700	2,530	2,660	2,180	2,060
Stocks, Dec 31:						
Industry	do.	583	618	677	735	929
Future exchanges	do.	8,640	8,760	9,380	10,500	10,400
Department of the Treasury	do.	840	1,030	775	NA	NA
Department of the Defense	do.	32	23	29	34	15
National Defense Stockpile	do.	2,870	2,610	2,260	1,850	1,670
Coinage		265	285	NA	NA	NA
Price, average per troy ounce 3/		$4.82	$4.04	$3.94	$4.30	$5.29
Employment 4/		2,600	1,900	1,600	1,100	1,000
World:						
Mine production	metric tons	16,600 r/	15,600 r/	14,600 r/	14,300 r/	13,900 e/

e/ Estimated. r/ Revised. NA Not available.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Not comparable with previous Silver Annual Reports, which represented old scrap only.

3/ Platt's Metals Week Annual Handy & Harman quotation.

4/ Mine Safety and Health Administration.

TABLE 2
MINE PRODUCTION OF SILVER IN THE UNITED STATES, BY STATE 1/
(Kilograms)

State	1993	1994
Arizona	200,000	192,000
California	14,500	11,200
Idaho	190,000	159,000
Missouri	40,300	40,300
Montana	127,000	70,600
Nevada	713,000	673,000
New Mexico	22,300	22,000
Oregon	--	57
South Dakota	4,710	4,090
Washington	14,000	W
Other States 2/	319,000	307,000
Total	1,640,000 r/	1,480,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Other States."

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes Alaska, Colorado, Illinois, Michigan, New York, South Carolina, Utah, Tennessee, Wisconsin, and State indicated by symbol "W."

TABLE 3
TWENTY-FIVE LEADING SILVER-PRODUCING MINES IN THE UNITED STATES IN 1994, IN ORDER OF OUTPUT

Rank	Mine	County and State	Operator	Source of silver
1	McCoy and Cove	Lander, NV	Echo Bay Mining Co.	Gold ore.
2	Rochester	Pershing, NV	Coeur Rochester Inc.	Do.
3	Bingham Canyon	Salt Lake, UT	Kennecott -Utah Copper Co.	Copper ore.
4	Candelaria	Mineral, NV	Kinross Delamar Mining Co.	Gold ore.
5	Red Dog	NW Arctic, AK	Cominco Alaska Inc.	Lead-zinc ore.
6	Sunshine	Shoshone, ID	Sunshine Mining Co.	Silver ore.
7	Mission Unit 1/	Pima, AZ	ASARCO Incorporated	Copper ore.
8	Kinross -Delamar	Owyhee, ID	Kinross Delamar Mining Co.	Gold ore.
9	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Lead-zinc ore.
10	Montana Tunnels	Jefferson, MT	Pegasus Gold Corp.	Zinc ore.
11	White Pine	Ontonagon, MI	Copper Range Co.	Copper ore.
12	Denton-Rawhide	Mineral, NV	Kennecott Rawhide Mining Co.	Gold ore.
13	Sierrita	Pima, AZ	Cyprus Minerals Co.	Copper ore.
14	Morenci	Greenlee, AZ	Phelps Dodge Corp.	Do.
15	Continental	Silver Bow, MT	Montana Resources Inc.	Do.
16	San Manuel	Pinal, AZ	Magma Copper Co.	Do.
17	Ray Unit	do.	ASARCO Incorporated	Do.
18	Zortman-Landusky	Phillips, MT	Pegasus Gold Corp.	Gold ore.
19	Flambeau	Rusk, WI	Kennecott Corp.	Copper ore.
20	Chino	Grant, NM	Phelps Dodge Corp.	Do.
21	Pinto Valley	Gila, AZ	Magma Copper Co.	Do.
22	Superior	Pinal, AZ	do.	Do.
23	Republic	Ferry, WA	Hecla Mining Co.	Gold ore.
24	San Xavier	Pima, AZ	ASARCO Incorporated	Copper ore.
25	Leadville	Lake, CO	do.	Zinc ore.

1/ Includes Eisenhower, Mission, Pima, and San Xavier Mines.

TABLE 4
U.S. EXPORTS OF SILVER, BY COUNTRY 1/ 2/

Year and country	Ore and concentrates 3/		Dore and precipitates		Refined bullion		Total		Waste and scrap	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
1993	2,270	$395	103,000	$16,000	705,000	$100,000	811,000	$117,000	892,000	$142,000
1994:										
Belgium	--	--	--	--	--	--	--	--	143,000	21,500
Brazil	--	--	--	--	4,980	904	4,980	904	--	--
Canada	--	--	--	--	97,600	17,700	97,600	17,700	453,000	65,500
Chile	--	--	--	--	1,210	283	1,210	283	--	--
China	--	--	--	--	13,900	2,580	13,900	2,580	24,300	3,260
France	--	--	61,100	10,800	--	--	61,100	10,800	10,800	1,760
Germany	--	--	27	4	256	21	283	25	176,000	30,500
Hong Kong	--	--	--	--	12,200	2,300	12,200	2,300	1,420	180
India	--	--	--	--	1,320	226	1,320	226	324	42
Italy	78	16	--	--	--	--	78	16	3,100	573
Japan	98	20	4,520	775	323,000	59,600	328,000	60,400	122,000	23,200
Korea, Republic of	--	--	--	--	84,000	14,600	84,000	14,600	63	44
Netherlands	--	--	--	--	--	--	--	--	4,190	448
Singapore	--	--	--	--	500	90	500	90	5	8
South Africa, Republic of	--	--	--	--	--	--	--	--	1,370	178
Sweden	--	--	--	--	--	--	--	--	28,100	5,260
Switzerland	--	--	591	98	446	76	1,040	174	9,450	1,970
United Arab Emirates	--	--	--	--	150,000	24,700	150,000	24,700	--	--
United Kingdom	--	--	22,100	3,770	131,000	21,400	153,000	25,200	230,000	56,300
Uruguay	--	--	10,800	2,020	46,600	10,000	57,400	12,000	--	--
Other	20	5	--	--	444	94	464	99	1,670	222
Total	196	41	99,100	17,500	868,000	155,000	967,000	172,000	1,210,000	211,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Bullion also moves in both directions between U.S. Markets and foreign stocks on deposit in the Federal Reserve Bank. Monetary silver excluded.

3/ Includes base metals ores, concentrates, and matte imported for refining.

Source: Bureau of the Census.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF SILVER, BY COUNTRY 1/ 2/

Year and country	Ore and concentrates 3/		Dore and precipitates		Refined bullion		Total		Waste and scrap	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
1993	35,700	S6,410	281,000	S78,600	2,180,000	$297,000	2,500,000	$382,000	1,270,000	$46,000
1994:										
Argentina	--	--	--	--	--	--	--	--	514	6,790
Brazil	--	--	--	--	1,820	296	1,820	296	--	--
Bulgaria	--	--	710	125	--	--	710	125	--	--
Canada	12,300	2,220	57,800	10,200	903,000	151,000	973,000	163,000	116,000	8,040
Chile	3,300	693	290,000	93,600	58,500	10,400	352,000	105,000	4,630	686
Costa Rica	--	--	--	--	455	67	455	67	40,700	109
Dominican Republic	--	--	40,300	16,200	20,200	2,620	60,500	18,800	270	305
Estonia	--	--	--	--	--	--	--	--	78,200	2,300
France	--	--	--	--	--	--	--	--	16,200	144
Germany	82	108	--	--	(4/)	1	82	109	264,000	4,370
Ireland	--	--	--	--	--	--	--	--	691	776
Malaysia	--	--	--	--	--	--	--	--	233,000	13,400
Mexico	117,000	21,100	18,600	3,230	711,000	122,000	847,000	146,000	11,500	6,710
Namibia	--	--	2,510	476	--	--	2,510	476	2,260	3
Netherlands	--	--	--	--	--	--	--	--	31,500	675
Peru	--	--	3,310	573	362,000	61,100	365,000	61,700	1,040	144
Philippines	--	--	--	--	--	--	--	--	26,900	407
Russia	--	--	--	--	--	--	--	--	77,400	2,160
Sweden	--	--	--	--	--	--	--	--	2,780	36
United Kingdom	75	6	--	--	61	10	136	16	163,000	6,530
Other	--	--	134	81	457	80	591	161	1,010	1,500
Total	133,000	24,100	413,000	124,000	2,060,000	347,000	2,600,000	495,000	1,070,000	55,100

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Bullion also moves in both directions between U. S. Markets and foreign stocks on deposits in the Federal Reserve Bank. Monetary silver excluded.

3/ Includes base metals ores, concentrates, and matte imported for refining.

4/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 6

SILVER: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Algeria e/	3	3	4	4	4
Argentina	83 r/	70	45 r/	43 r/	43
Australia	1,170	1,180	1,220 r/	1,090 r/	1,060
Austria	-- r/	-- r/	-- r/	-- r/	--
Bolivia	311	376	282	333 r/	350
Brazil 4/	171	154	162 r/	165 r/	170
Bulgaria e/	54	37	35	35	30
Burma	6	5	5	2 r/	4
Canada (shipments)	1,500	1,340	1,220 r/	896 r/	758 5/
Chile	655	678	1,030	970 r/	980
China e/	130	150	170	200	210
Colombia 6/	7	8	8	7 r/	7
Costa Rica e/	(7/)	(7/)	(7/)	(7/)	(7/)
Croatia	XX	XX	1	1	1
Czech Republic e/	XX	XX	XX	1 r/	1
Czechoslovakia e/ 8/	16	9	6	XX	XX
Dominican Republic	22	22	15	13 e/	10
Ecuador e/	(7/)	(7/)	(7/)	(7/)	(7/)
Fiji	1 r/	(7/) r/	1	1	1
Finland 9/	29	30 r/	27	29 r/	26
France	26	29	16	13 r/	12
Germany:					
Eastern states	35	XX	XX	XX	XX
Western states	6	XX	XX	XX	XX
Total	41	4	1	--	--
Ghana e/	1	1	2	2	2
Greece	63	70	62 r/	59 r/	55
Greenland	9	--	--	--	--
Honduras	31 r/	39	43 r/	24 r/	25 5/
India	33	32	47 r/	51 r/	52
Indonesia	67	80	100	90 r/	100
Iran e/	38	40	50	60	60
Ireland	8 e/	11	13	13 r/	12
Italy 10/ 11/	14 r/	14 r/	12 r/	5 r/	5
Japan	150	171	178	137 r/	133 5/
Kazakhstan e/ 6/	XX	XX	900	900	800
Korea, North e/	50	50	50	50	50
Korea, Republic of 6/	238	265	333	330 e/	340
Macedonia e/	XX	XX	10	10	10
Malaysia	13	13	15	14 r/	13 5/
Mali e/	(7/)	(7/)	(7/)	(7/)	(7/)
Mexico	2,420	2,300	2,100	2,420 r/	2,330 5/
Morocco	241	296	213	309 r/	309
Namibia	92	91	89	72	62 5/
New Zealand	5	11	22 r/	26 r/	30
Nicaragua	1	1	2	2	2
Papua New Guinea	115 r/	125	95	96 r/	78
Peru	1,930 r/	1,930 r/	1,610 r/	1,630 r/	1,700
Philippines	47	38	31	33	30
Poland	832	899	798	767 r/	770
Portugal	42	43 e/	38	35 e/	32
Romania e/	80	80	73	70	70 5/
Russia e/	XX	XX	800	800	800
Saudi Arabia	16	16	16	18	18
Serbia and Montenegro	XX	XX	66	25 r/	18
Slovenia e/	XX	XX	(7/)	--	--
Solomon Islands	(7/)	(7/)	(7/)	(7/) e/	--
South Africa, Republic of	161	171	183	192 r/	196 5/
Spain	500 e/	208 e/	160	159 r/	160
Sweden	243	239	210 r/	255 r/	276 5/
Taiwan	4	--	--	--	--
Tunisia e/	1 5/	1	1	1	1
Turkey e/	53	64	103	103 r/	105

See footnotes at end of table.

TABLE 6--Continued
SILVER: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
U.S.S.R. e/ 6/ 12/	2,500	2,200	XX	XX	XX
United States	2,120	1,860	1,800	1,640 r/	1,480 5/
Yugoslavia 6/ 13/	105	84	XX	XX	XX
Zaire e/	84	80	60	50 r/	60
Zambia 14/	17	14	21	16 r/	14
Zimbabwe	21	19	17	12 r/	14
Total	16,600 r/	15,600 r/	14,600 r/	14,300 r/	13,900

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Recoverable content of ores and concentrates produced unless otherwise specified. Table includes data available through June 12, 1995.

3/ In addition to the countries listed, Botswana produces silver (probably 1 kilogram or less per year) and Thailand may produce silver, but information is inadequate to make reliable estimates of output levels.

4/ Of total production, the following quantities, in kilograms, are identified as placer silver (the balance being silver content of other ores and concentrates): 1990--52,000; 1991--40,000; 1992--42,000; 1993--43,000 (revised); and 1994--45,000 (estimated).

5/ Reported figure.

6/ Smelter and/or refinery production.

7/ Less than 1/2 unit.

8/ Dissolved Dec. 31, 1992. All production from 1990-92 came from the Czech Republic.

9/ Metal content.

10/ Includes production from imported ores.

11/ Series revised to reflect mine production; previous series numbers were refined metal production.

12/ Dissolved in Dec. 1991.

13/ Dissolved in Apr. 1992.

14/ Year beginning Apr. 1 of that stated.

SLAG—IRON AND STEEL

By Cheryl Solomon

Iron and steel slags are byproducts of the iron and steel industry. They are used not only in construction and roadbuilding, but also in other ways such as in waste stabilization. Slags are used in road bases, various types of concrete aggregates, fill, glass manufacture, mineral wool, railroad ballast, and soil conditioning.

Research during the year emphasized blast furnace slags incorporated into blended cements, and used in oil well drilling, and waste stabilization, as well as various uses of steel slags.

Total slag consumption increased by 6%, partly due to increased demand for slag in the construction industry and increased quantities of slags available. Domestic consumption of reported iron slag stayed the same when compared with that of 1993, while the consumption of reported steel slag increased by 17%.

Legislation and Government Programs

The Environmental Protection Agency proposed a ruling, the Comprehensive Guideline for Procurement of Products Containing Recycling Materials. The guideline designated items that could be made with recovered materials and recommended procurement practices. The guideline incorporated five areas: cement and concrete, paper and paper products, re-refined lubricating oil, retread tires, and building insulation. The proposed action was to foster markets for materials recovered from solid waste by using government purchasing power to stimulate use of these materials in the manufacture of new products. Ground granulated blast furnace slag was included among the recycled products that could be used in cement and concrete for a variety of applications.[1]

Production

Slag was produced in 29 States *(See tables 2 and 3.)* and by 17 companies.

The Edward C. Levy Co., based in Detroit, MI, with slag operations in Australia, Indiana, Michigan, and Ohio, marketed blast furnace and steel furnace slag as well as limestone and sand and gravel in the Midwest, Southeast, and Western States. New ventures included various electric furnace mini-mill operations throughout the United States.

The majority of the Edward C. Levy's blast furnace slag products were used in concrete asphalt highway and roadway paving products with some expanded blast furnace slag used as a lightweight aggregate in masonry block production. The steel furnace slag was used primarily as an aggregate in hot mix asphalt and as a general maintenance base material.

Koch Minerals Co. based in Wichita, KS, was involved in a number of projects involvingblast furnace slag. The National Rock and Roll Hall of Fame located in Cleveland, OH, utilized ground granulated blast furnace slag as a replacement for portland cement throughout the structure's concrete. Seventy percent replacement levels were used for the low heat mass portions of the project. A 40% replacement level was used for structural columns, and 30% replacement level was used for project flat work. The Hap Cremean Waste Water Treatment Plant located in Columbus, OH, used concrete to construct holding ponds, treatment tanks, and ancillary structures. The concrete mix design used a 30% ground granulated blast furnace slag replacement of Type I portland cement in lieu of using 100% moderate sulfate resistant Type II portland cement. Koch Minerals also supplied air-cooled slag aggregate for the 6.8 mile four-lane hot mix reconstruction project of Interstate-94 between Michigan City Route 35 and the Michigan State line. One hundred percent slag aggregate was used on this project for pavement base, binder, and surface courses. Natural sand was used for the hot mix fine aggregate fraction. A total of 168,000 metric tons of hot mix aggregate was placed. Approximately 95,000tons of air-cooled slag aggregate was used.

The Levy Co. of Portage, IN, was involved with efforts to use slag more widely in the States of Illinois and Indiana. The Indiana Dept. of Transportation (INDOT) altered existing base design for concrete pavement with the intent to reduce moisture infiltration through the bottom layer of the dense graded aggregate subbase. As a result of a cooperative research effort between INDOT and the Levy Co., INDOT established a new specification for this application, allowing slag to be utilized under a modified gradation. It was anticipated that INDOT's acceptance of the modified gradation would preserve 50,000 to 100,000 tons of potential slag base business on an annual basis. The Levy Co. received approval from the Illinois Department of Transportation's Greater Chicago District to supply blast furnace slag chips as an alternate to slag furnace slag chips for high volume asphalt surface mixes. The most notable project to utilize the blast furnace chips was the Kennedy Expressway in Chicago, IL, which covered 6 miles of pavement. The $5.5 million reconstruction project required 23,000tons of blast furnace chips and was completed in 2 months.

Consumption

Data for sales, use, and transportation of iron and steel slag are developed by the U.S. Bureau of Mines from a voluntary survey of U.S. processors. Of the 93 operations canvassed, 88 responded, representing 96% of the total sales or use, quantity data shown in table 1. Quantity data were estimated for the remaining operations. Value data had to be estimated for several operations using reports from prior years adjusted by industry trends. (See table 1.)

Sales of slag products generally reflected demand from the construction industry. The Department of Commerce reported that value of new construction in 1994, $507 billion, increased by 9% compared with that of 1993.[2] The value of highway and street construction, $40.19 billion, was estimated to have increased by approximately 8% from that of 1993.

Many of the projects involving slag in 1994 were related to highway repaving projects. Blast furnace slag was used as a ground product to replace portland cement in concrete, as a special lightweight aggregate in blocks and highrise buildings, as a concrete aggregate replacing common concrete aggregates and sands, as a highly skid-resistant asphalt aggregate, and as a road base where the rough, interlocking surface and shape and cementitious properties enhance its load-bearing values.

Air-cooled blast furnace slag was the predominant form of iron slag processed in the United States, accounting for 87% of blast furnace slag sales in 1994. In 1994, 10.7 million tons of air-cooled slag was used with a value of $62.4 million. The most significant end use in 1994 was for air-cooled slag used as a road base. Air-cooled blast furnace slag also was used as an asphaltic concrete aggregate, other concrete aggregate and concrete products, fill, mineral wool, railroad ballast, glass manufacture, and sewage treatment. *(See table 4 for related data.)*

Consumption of combined expanded and granulated slag was 1.6 million tons valued at $51.1 million. Granulated slag was predominantly used in the manufacture of cement and expanded slag in the manufacture of lightweight concrete blocks.

Steel slag was principally used for highly skid-resistant asphalt road surfaces, road bases, and asphaltic aggregates. Reported steel slag consumption increased by almost 17% compared with that of 1993. *(See table 5.)* Steel slag used on road bases, in fill, in asphaltic concrete aggregate, and railroad ballast increased by 19%, 46%, 4.6%, and 38%, respectively.

Transportation

Most slag is used within about a 50 kilometer (km) radius of its source. Trucking costs make slag uncompetitive with mined aggregates when transportation distances exceed about 50 km. Some slag may be delivered over greater distances to areas that do not have other aggregates for use in construction and roadbuilding.

Of all the iron and steel slag products sold in 1994, 85% traveled by truck, with an average marketing range of 45 km; 4% traveled by waterway, with an average range of 404 km; and 4% traveled by rail, with an average range of 400 km. The remaining 7% was used at the plant where it was processed. *(See table 6.)*

Prices

The average price, f.o.b. plant, for all blast furnace slag was approximately $9.23 per ton, almost 10% more than that of 1993. *(See table 7.)* Air-cooled blast furnace slag averaged $5.84 per ton, virtually the same as that in 1993. Granulated and expanded slag price information were withheld to avoid disclosing company proprietary data. The unit value for steel slag was $3.45 per ton, virtually the same as in 1993.

Foreign Trade

Statistics developed by the U.S. Department of Commerce, Bureau of the Census, indicated that approximately 199,000 tons of granulated blast furnace slag was imported during 1994. Seventy-one percent of these imports came from Canada, 15% from the Republic of South Africa, and most of the remainder from Norway. Forty percent of the imports entered through Savannah, GA; 31% through Baltimore, MD; 23% reportedly entered through Cleveland, OH; and the remainder through Buffalo, NY, and Philadepphia, PA. The Canadian imports may be expanded or pelletized slag.

Exports of granulated slag were 4,000 tons. Seventy percent of the slag exports went to Canada, 20% to Japan, with the remaining 10% going to 12 other countries.

World Review

Blast furnace slag production in Europe, including Austria, Belgium, Finland, France, Germany, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom increased by approximately 5%. Approximately 26.2 million tons of blast furnace slag was produced. It was estimated that 31% of this was granulated slag. Basic oxygen steel slag production was estimated at 10.1 million tons.

Australia.—Approximately 3 million tons of iron and steel slag was produced, about the same as that in 1993. There were no significant changes in slag production from 1993 at the iron and steel production centers in Australia. About 375,000 tons of blast furnace slags was used in Australian cements, with another 500,000 tons used in road construction and as an aggregate in concrete. Slag production and consumption centered around the iron and steel slag produced by BHP Steel in two areas in Australia—Port Kembla and Newcastle in New South Wales.

The BHP plant at Whyalla, South Australia, also produced 350,000 tons of blast furnace rock slag and 125,000 tons of basic oxygen furnace slag. The plants' isolation from population centers and markets meant that the slag produced was landfilled.

In the Port Kembla area of New South Wales, the slag processor was Australian Steel Mill Services (ASMS), a consortium of Edward C. Levy Co. of Detroit, MI, and Queensland Cement Co., a wholly owned subsidiary of Holderbank Co. Approximately 1.3 million tons of blast furnace slag was processed into 700,000 tons of air-cooled slag and 600,000 tons of granulated slag. Approximately 50% to 60% of both types was used for road pavements, concrete aggregate, and cement manufacture, and the rest was stockpiled. Approximately 500,000tons of basic oxygen furnace slag was produced, with 100,000 tons used for road pavements and the rest stockpiled.

Significant progress was made in the recognition of blast furnace slag as a heavy-duty pavement material with its use as a subbase layer for the third runway at Sydney's major airport. About 300,000 tons of a blast furnace slag mix was supplied to the project. Competition from other aggregates, including mined aggregate, was intense for this and all other civil projects in the Port Kembla area.

BHP Steel began construction of its No. 6 blast furnace at Port Kembla. The furnace had a nominal rating of 7,000 tons of iron per day and was scheduled to begin operations in late 1996. When fully operational, two smaller furnaces, Nos. 2 and 4, were to be closed down. The No. 6 blast furnace had about the same capacity as Nos. 2 and 4; therefore, overall production of iron and slag was to remain unchanged.

In Newcastle, there were three slag contractors, Boral Quarries, of Boral Ltd.; Steel Cement, Ltd. (owned mainly by a consortium of Australian and Japanese companies); and Steelstone Services of Australia. The first two contractors produced approximately 500,000 tons of blast furnace slag; 50% was air-cooled slag used in road pavements and construction and 50% was granulated slag used in cement manufacture and road construction. The latter contractor produced about 200,000tons of steel slag, of which 100,000 tons was used for road construction and the balance was stockpiled.

All blast furnace slag produced in Newcastle was productively used in the marketplace, and more could have been sold if it had been available. Sales were assisted by the shortage of natural rock close to the main market area. Small shipments of granulated blast furnace slag were exported to Hawaii where its silicate content was used as a soil conditioner.

The State Roads and Traffic Authority of New South Wales was making extensive use of road pavement material in the Newcastle region comprising 70% basic oxygen furnace slag, 25% granulated blast furnace slag, and 5% fly ash. The use of the steel furnace slag mix as road pavement material was expected to be expanded. All of the components in the mix were byproducts from the BHP steel mill.

Electric arc furnace slag was also produced in Melbourne, Victoria, and Newcastle and Sydney in New South Wales.

Deep lift road stabilization was being increasingly used by the State Roads and Traffic Authority in several Australian states. Ground granulated blast furnace slag was frequently used either by itself or in combination with lime or fly ash.

Blast furnace slag cement marketed in Australia conformed to Australian Standard AS 1317. AS 1317 permitted slag to represent 20% to 65% of the total cementitious content.[3]

Following the release of a booklet entitled "A Guide to the Use of Slag in Roads", the Australasian Slag Association prepared a second booklet, "A Guide to the Use of Blast Furnace Slag in Cement and Concrete". It was to be released in 1995.

Austria.—Blast furnace slag and basic oxygen furnace steel slag consumption amounted respectively to 1.1 million and 0.395 million tons per year.

Belgium.—All production of blast furnace slag, about 2.4 million tons in 1994, was granulated and utilized by the cement industry in order to produce metallurgical cement. The most common cement sold on the Belgian market contained 40% crushed granulated blast furnace slag.

Basic oxygen furnace slag production remained similar compared with prior years, although some additional quantities of electric arc furnace slags were produced as a consequence of the startup of various electric arc furnace plants in Belgium and Luxembourg. The applications for steel slag remained principally for forest, farm and industrial roads, parking lots, stabilization of deposits, and hydraulic engineering. With the increasing availability of various secondary materials for civil construction, it was foreseen that there would be more competition for use of blast furnace slag.

France.—In 1994, approximately 2.37 million tons of granulated, 1 million tons of air-cooled, and 0.5 million tons of slag that was pelletized or processed in other ways was produced. Sollac had two granulating operations at Dunkerque and Fos, producing 0.960 and 0.460 million tons in 1994. Hayange at Rombas granulated 0.950 million tons of slag. Lafarge planned to build a 0.4 million ton granulator at Fos in 1996 or 1997, and Sollace was to build another one at Dunkerque.

Germany.—There were 7.77 million tons of blast furnace slag produced in Germany and 7.52 million tons sold, compared with 6.81 and 7.41 million tons, respectively, in 1993. Almost 93% of the slag produced came from nonphosphorus pig iron production, 2% from basic Bessemer pig iron production, and 2% from special pig iron production. There was an additional 3% from stocks of slag produced in prior years. About 48% of the slag was air-cooled slag used for road construction, 47% was granulated slag for cement, and nearly 4% was granulated slag for road construction. Foamed slag for road construction was not produced in 1994, and less than 1% was air-cooled slag for fertilizer.

There was 4.86 million tons of steel slag produced in Germany, and 4.64 million tons sold, compared respectively with 4.24 million produced and 3.73 million sold in 1993. Sixty percent was used as aggregate for roads, 19% was recycled back to the blast furnace, 11% was used for landfill, 6% was used as fertilizer, and 4% was for other uses.

Slag used in Germany must conform to special requirements for leachability, in addition to conforming to certain technological requirements. The leaching was done according to German Standard DIN 38 414. There were no common limits within Germany for the application of byproducts. Therefore, the state of Northrhine-Westfalia (Nordrhein-Westfalen) created special limits for each of 11 byproducts. According to the leachability of the slags, they could be used as aggregates in nearly all fields of applications as in road construction in asphalt or unbound layers.

India.—The Tata Group, one of the largest industrial forces in India, operated an integrated steel plant at Jamshedpur, Bihar in India. More than 0.72 million tons of slag per year was granulated. A 1.73-million-ton-per-year cement plant was built in order to utilize this granulated blast furnace slag. The unit of the plant which was to produce 1 million tons of clinker per year and 0.3 million tons per year of portland cement unit was installed at Sonadih, Madhya Pradesh, and a grinding plant able to produce 1.43 million tons per year of portland cement was installed at Jojobera, Bihar.[4]

Japan.— A total volume of 4 million tons of ground granulated blast furnace slag was produced with about 400,000 tons being exported to Southeast Asia.

Netherlands.—Blast furnace slag production amounted to about 1.2 million tons. Ninety-six percent of the iron slag was granulated and almost entirely sold to the cement industry. A small quantity was used in admixtures for road building. The remaining slag was air-cooled and used as a component for road building.

Steel slag production from basic oxygen furnace steelmaking amounted to about 530,000 tons. About 15% of this steel slag was returned to the furnace as process slag, 30% was used in marine engineering, and 15% was used in road construction as the main component in mixtures with granules. The remaining 40% was put in stock and could be used in large projects as a replacement for sand.

Much attention was given to upgrade steel slag by means of separation, quality control and aging so that it would be an acceptable replacement for natural aggregates used in road construction, concrete products, and cement production.

United Kingdom.—The amount of blast furnace slag produced in 1994 was approximately 3.46 million tons, about 5% more than that in 1993. The percentage of granulated slag and pelletized slag was about 31% of the total blast furnace slag. Slag was granulated and pelletized at Redcar, Scunthorpe, Llanwern and Port Talbot, with respectively, 0.3 million, 0.4 million, 0.25 million, and 0.2 million tons being produced.

Approximately 1.6 million tons of basic oxygen slag was produced, about 7% more than in 1993. British Steel Teeside marketed approximately 10,000 to 20,000 tons of basic oxygen slag as an agricultural liming fertilizer.

The principal means of regulating slag was the British Standard (BS). In addition, other Digests issued by the Building Research Establishment, although not carrying the force of a BS, were conformed to by slag processors. BS 6699 was used for blast furnace slag used in cement, ground granulated blast furnace slag (ggbfs). This ggbfs was for supply directly to the concrete manufacturer, ready-mixed, site-mixed, or precast. The BRE Digest No. 363 covered sulfate resistance of concrete and specified a 14% maximum Al_2O_3 content. BS 1047 covered air-cooled blast furnace slag for aggregates.

Current Research and Technology

A study was conducted at the Ashikaga Institute of Technology in Ashikaga, Japan.[5] Its purpose was to examine closely the basic properties of ordinary portland cement concrete, which contains finely granulated blast furnace slag and then to identify an appropriate method of applying the blast furnace slag to concrete. In the experiment, the ratio of cement replaced with ground granulated blast furnace slag was 30%, 50%, or 70%, the ratio of water to the cement plus ground granulated blast furnace slag was 35%, 45%, or 55%, the slump 18 plus or minus 2.5 centimeters (cm) and the air content approximately 5%. It was determined that when used as an additive for concrete, the fine granulated blast furnace slag could provide the specific concrete quality which met the application purpose.

Work was done at the Universitat GH Siegen in Germany to develop an injection mortar based on blast furnace slag, gypsum and Portland cement.[6] In the second part of the work, the aggregate was varied while retaining the same binder composition. The purpose was to reduce the water demand without impairing the other properties of the mortar. Various nodular materials and additives were used for this purpose. The fresh mortar was tested for water retention capacity, air void content and bulk density, and the hardened mortar for swelling and contraction, dynamic elastic modulus, compressive and flexural tensile strengths, water absorption, tendency to efflorescence, leaching behavior and porosity. From the results, it was seen that partial replacement of the standard sand by fly ash did not result in improvement in the water demand, but partial replacement of the standard sand by solid glass microspheres reduced the water demand without impairing the other properties tested.

Various results were obtained by using blast furnace slag for oil field use. Two refined and practical conversion methods of drilling mud to oilwell cement were proposed.[7] According to the Fluids Research Association, each method claimed universal applicability and performance superior to that of conventionally mixed and pumped portland cement. Blast furnace slag and portland cement were used for the drilling mud conversion.

An investigation of slurries using field and laboratory prepared drilling fluids solidified with blast furnace slag was undertaken at the Mobil E&P Technical Center.[8] In the investigation, data included base mud properties, final slurry composition, and slurry properties. Measurements were taken of the common properties of thickening times, compressive strength, free water, among others. It also included an evaluation of the bulk shrinkage of the set material, shear bond, as well as rheological compatibility studies of the finished slurries with the base muds. The additional tests were considered critical in the potential application of the process under field conditions. Operational considerations and the economics of required mud isolation and storage were reviewed. From the laboratory data evaluated, and environmental and economic evaluations, it was apparent that the use of blast furnace slag slurries for oil field applications was to be carefully evaluated on a case by case basis. The replacement of portland cement by the blast furnace slag slurry was thought to compromise some properties considered essential in a cementing operation.

Thorough testing, economic evaluations, and environmental evaluations of blast furnace slag slurries revealed that replacing portland cement with slag slurries may compromise essential properties in a cementing operation.[9] It was determined that the use of blast furnace slag slurries should be analyzed on a per case basis for oil well cementing operations. Test results indicated that blast furnace slag slurries could be designed to give good placement times and show compressive strength development over a wide temperature range. Stress cracking of blast furnace slag slurries was severe and occurred in atmospheric, pressurized, and constant temperature testing.

Blast furnace slag based cements were used by Shell Oil on over 160 oil well cementing operations as part of an effort to develop and expand the understanding of blast furnace slag cements.[10] Blast furnace slag cements decreased the remedial squeezing of casing shoes by 61% on exploratory wells drilled with subsea wellheads in the Gulf of Mexico.

Application of blast furnace slag in the cementing of oil and gas wells emphasizing the suitability of blast furnace slag for offshore operations in the North Sea was studied at the Rogaland Research Institute.[11] The study outlined the chemical reactions which occur during curing of blast furnace slag and discussed effects of different blast furnace slag sources and testing requirements. The application of blast furnace slag as a drilling fluid additive to improve cement bonding by solidification of the filter cake was discussed with respect to the effects of blast furnace slag on drilling fluid rheology and fluid loss. Blast furnace slag was found to be suitable for low volume operations such as plug cementing, however wider use of blast furnace slag was seen to be limited by logistics and occupational safety aspects for offshore North Sea applications.

The influence of the addition of 15% and 30% fly ash, 15% and 30% of a Greek natural pozzolan and 50% granulated blast furnace slag to ordinary Portland cement on the corrosion resistance of the reinforcing bars was studied in a program of long-term exposure to seawater.[12] The use of blended cements resulted in a decrease in the corrosion rate, especially after long exposure times. The most effective protection was provided by the 30% fly ash mix. This performance was related to the chloride content and the chloride binding capacity of the blended cements.

A study reported on by the British Cement Association in Berkshire, England, was concerned with measurements of corrosion in steel rods embedded at 2, 4, 8, and 12 millimeters (mm) from the exposed surface of concrete dried and carbonated uniaxially for 0.5, 1.5 and 4 years.[13] Corrosion was stimulated by exposing all specimens to a moist environment for a prescribed period prior to extraction and cleaning of the rods for gravimetric corrosion measurements. The work examined the effects of five water/cement ratios, four cements, three periods of moist curing, and five exposure conditions upon the carbonation-induced corrosion of the steel rods. Corrosion seemed to increase when there was 50% ground granulated blast furnace slag in the cement; in contrast, 30% pulverized fuel ash or 5% ground limestone had little effect.

Investigations were carried out at the King Fahd University of Petroleum and Minerals in Dhahran, Saudi Arabia, on blended cements incorporating blast furnace slag. One study was designed to evaluate the relative corrosion and sulfate resistance of concrete made with portland cements with and without 50%, 60%, 70%, and 80% cement replacement by blast furnace slag.[14] The results showed that blast furnace slag blended cement concretes had a significantly superior corrosion-resistance performance. The best corrosion protection was obtained with 50% blast furnace slag cement, which showed a 3 to 4 times better performance in terms of corrosion-initiation time compared with the parent plain cement concrete. Blast furnace slag blending was especially beneficial in improving the corrosion-resistance performance of Type V cements. Performance on exposure to sodium-sulfate solution, replacement level, only at 70% and above, showed sulfate resistance to be better than that of the Type V sulfate-resistant cement. Blast furnace slag blending imparted a high degree of sulfate resistance. However, with magnesium-gypsum type of attack, the 60% blast furnace slag cement deteriorated even more severely than the plain Type V and Type I cements.

Another investigation carried out at the King Fahd University had as its goal to determine the role of chloride ions in sulfate attack in plain and blended cements.[15] Paste and mortar specimens made with Type I and Type V cements as well as with Type I cement blended with fly ash, silica fume and blast furnace slag were exposed to four sulphate and/or chloride environments for a period of 2 years. The performance of these cements was evaluated through visual inspection and measurement of reduction in compressive strength. X-ray diffraction and scanning electron microscopic techniques were used to study the sulfate attack mechanisms in plain and blended cements in both the presence and the absence of chloride ions. Results indicated that sulfate deterioration in plain cements was mitigated by the presence of chloride ions, whereas in blended cements, particularly those made with silica fume and blast furnace slag, the beneficial effect of chloride was only marginal. This was attributed to the magnesium oriented sulfate attack that was more operative in blended cements.

Chloride-induced corrosion causes significant deterioration in transportation structures where uncoated reinforcing steel is used. Concretes with very low permeability were used to prevent the intrusion of chlorides into concrete to the level of the reinforcing steel. A study evaluated the strength and permeability of various combinations of silica fume and slag in concrete.[16] It was determined that when silica fume was added in small amounts of 3% to 5% to concretes with up to 47% slag at a water-cement ratio of 0.40 and 0.45, economical concretes with very low permeability and adequate strength could be produced.

Researchers at the University of Laval in Quebec City, measured pore solution chemistry, or high pressure extraction method, of cement pastes made with two condensed silica fumes, three pulverized fly ashes, and one ground granulated blast furnace slag, after a range of 7 to 545 days of curing at 38° C.[17] For all of the supplementary cementing materials (SCM's) in the study, a higher overall concrete alkali content, called for a higher cement replacement; an excessive alkali content could make the SCM totally ineffective, even with relatively high SCM contents.

Blended cement concretes incorporating blast furnace slag and condensed silica fume were tested for elastic modulus, creep and shrinkage strains, in order to compare their performance with that of plain Portland cement concretes.[18] Exposed and sealed specimens were investigated. The results showed that the exposure condition of the specimens during testing was critical. The addition of slag had the effect of causing a possible small increase in creep and shrinkage at early ages in exposed specimens, but this effect was usually reversed at later ages. Strains were markedly reduced in sealed slag specimens. The use of a blended cement resulted in less variability in cumulative strains.

The effect of cement, admixture, water-binder ratio and volume concentration of aggregate, on autogenous shrinkage of cement based materials was experimentally investigated.[19] A large amount of autogenous shrinkage was observed in cement paste and concrete with a very low water-binder ratio. Autogenous shrinkage was increased by using blast furnace slag with greater fineness. Other admixtures could decrease autogenous shrinkage.

Alkali-activated slag fly ash was developed to counteract the problem of severe attack on sewer concrete caused by biogenic sulfuric acid.[20] The hydraulic binder, Diabind, was composed of blast furnace slag, fly ash, sodium metasilicate, and a small amount of Portland cement clinker. The optimum composition of the binder was a compromise between acid resistance and strength. Diabind was successfully produced for use in concrete sewer pipes in industrial installations.

Research on artificial soft rock was carried out in Japan in order to investigate the durability of rock made from clay pulverized natural mud-rock, natural sand, water and new blended blast furnace slag cement mixtures.[21] In the experiment, the artificial soft rock specimens were exposed to various curing conditions in order to eliminate the temperature effect and to various water and weathering conditions in order to eliminate the resistance against the actions of various ground water and weathering for about 10 years. These studies proved that the artificial soft rock was highly resistant against the actions of various ground water and weathering. Their long-term durability was also verified by results of follow-up investigations, after exposing them in the field for 10 years.

Cements play a major role in the engineered structures for low and intermediate-level radioactive wastes.[22] Cement can effectively mobilize radionuclides as part of the overall multibarrier design of repositories. Immobilization timescales for radioactive wastes are long, of the order of 10^6 years for some radionuclides. Proof of the long-term performance of cements has placed new demands on investigations of cements used for this purpose. The chemistry of slag blends differs markedly from that of other blend types in its sulfide content. Most hydrated portland cements are mildly oxidizing. In slag cements, there is a critical blast furnace slag content beyond which a reducing environment is produced. High slag blends are particularly beneficial for treating wastes containing certain species.

At the GK Williams Cooperative Research Centre for Extractive Metallurgy in Victoria, Australia, research was conducted on blast furnace slags containing toxic elements.[23] Four slag types covering the range of Fe-Ca-Si-O compositions and two iron blast furnace slags were melted at 1,300° C and doped with 1% each arsenic, antimony, cadmium, zinc and chromium. The melts were either slow cooled or quenched, and the solidified slags were leached according to Toxic Characteristic Leachate Procedures. The morphology of the solidified slags was characterized using X-ray diffraction, optical and electron microprobe techniques. Theoretical considerations showed that the capacity of the molten slag to hold the above toxic elements depended upon slag basicity, which was confirmed in practice. The experiments showed that the leaching of the toxic elements was a function of surface area and the phases present, both of which were affected by the mode of cooling. Iron silicate slags produced in nonferrous smelting operations and blast furnace slag from ferrous smelting operations both have shown promise of being suitable media for immobilizing low levels of toxic elements and complying with regulatory requirements.

Blast furnace slags found many diverse uses in the ceramic industries. Iranian blast furnace slag was added for the first time to single fast fired wall tile compositions.[24] The chemical reactions occurring during firing and the formation of different phases were followed by differential thermal analysis, dilatometry, and X-ray diffractometry. The effects of composition on bend strength, water absorption, and firing shrinkage of differing compositions were investigated. An optimum slag content was found in the investigation to be 30%, which gave the best combination of less shrinkage, more water absorption, and lower bend strength.

Studies conducted at McMaster University in Hamilton, Ontario, dealt with the fact that when steel slag is used as an aggregate its properties depend upon its chemical and mineralogical composition.[25] The investigation used a detailed microscopic evaluation of specimens obtained from a steelmaking shop under well defined conditions. The variables of the study included chemical composition and cooling conditions.

Steel slag aggregate was used in premium surface course hot-mix asphalt for Ontario highways since the early 1970's. Asphalt pavement performance problems led to the Ministry of Transportation imposing a moratorium on the use of steel slag aggregate in late 1991. The problem was addressed from the steelmakers producing the slag through to hot-mix design and production.[26] Steel slag could make good aggregate for use in hot-mix asphalt if the volume expansion of the slag was controlled. Performance based testing of steel slag aggregate, particularly volume stability, was recommended as a measure of the aggregate quality and practices at the steelmaker and the slag processor were examined.

The International Iron and Steel Institute repeated a survey conducted in 1984, on the quantities and treatment of steel plant wastes and byproducts to determine changes in practice during the decade.[27] Results showed that there were reductions in some areas of byproducts generation, and in no area has the situation deteriorated since 1984. In particular, there was a reduction in blast furnace slag generation from an average of 311 kilograms per ton (kg/t) of hot metal. There was considerable improvement in recycling performance with respect to electric furnace dust. Its treatment is now well established and about 30% of all dust is processed to extract heavy metals.

At the National Center of Metallurgical Research in Madrid, Spain, blast furnace slag and electric arc furnace flue dust were vitrified through a gelification process. The use of slag or slag-derived gel produced a borosilicate glass with thermal properties similar to those of conventional sodium-calcium glass.[28] It was thought that the materials produced from blast furnace granulated slag could have an industrial application in the production of continuous filament fiber glass.

The latest developments in the disposal and application of iron and steel slag in Japan were described at the Shanghai Institute of Metallurgy in Shanghai, China.[29] Such developments included the air-granulated slag process, ultrafine blast furnace slag, color sand, recovery of the useful constituents in steel slag, water penetrating and antiwear material for pavement, spray abrasives for grinding ship surfaces, and water purification agents.

Outlook

Blast furnace slag consumption was expected to stay approximately the same in the next few years, with little increase in production of blast furnace slag and consistent usage. Granulated slag might increase its proportion of the total blast furnace market over the next few years as the cement industry seeks to utilize it to replace portland cement. The stockpiling of steel slag may continue as the production of the steel slag has outstripped its demand.

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TABLE 1
IRON AND STEEL SLAGS SOLD OR USED 1/ IN THE UNITED STATES 2/

(Thousand metric tons and thousand dollars)

	Blast furnace slag									
Year	Air-cooled		Expanded 3/		Total iron slag		Steel slag		Total slag	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1993	10,500	61,700	1,860	41,900	12,300	104,000	6,670	22,900	19,000	126,000
1994	10,700	62,400	1,600	51,100	12,300	114,000	7,800	26,900	20,100	140,000

1/ Value based on selling price at plant. Includes estimated value data for several operations.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes granulated to avoid disclosing company proprietary data.

TABLE 2
BLAST FURNACE SLAGS SOLD OR USED IN THE UNITED STATES, BY REGION AND STATE 1/

(Thousand metric tons and thousand dollars)

	1993				1994			
	Air-cooled, screened and unscreened		Total, all types		Air-cooled, screened and unscreened		Total, all types	
	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/
North Central:								
Illinois, Indiana, Michigan, Ohio	6,920	40,500	8,080	55,300	6,940	40,600	7,600	54,800
Middle Atlantic:								
Maryland, New York, West Virginia, Pennsylvania	2,030 r/	13,000 r/	2,990 r/	41,600 r/	2,040	13,400	3,000	50,700
Undistributed 3/	1,530 r/	8,170 r/	1,270 r/	6,670 r/	1,720	8,490	1,700	8,090
Grand total	10,500	61,700	12,300	104,000	10,700	62,400	12,300	114,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Value based on selling price at plant.

3/ Includes Alabama, California, Kentucky and Utah.

TABLE 3
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 1994

Company	Plant location	Slag source				Blast furnace slag type
		Iron blast furnace	Steel			
			Basic oxygen furnace	Open hearth	Electric arc furnace	
Alexander Mill Service	Blytheville, AR				X	--
Do.	Kankakee, IL				X	--
Do.	Charlotte, NC				X	--
Do.	Holsopple, PA				X	--
Do.	Washington, PA				X	--
Do.	Cayce, SC				X	--
Do.	Darlington, SC				X	--
Do.	Seguin, TX				X	--
Do.	Plymouth, UT				X	--
Blue Circle Atlantic Inc.	Sparrows Point, MD	X				Granulated.
Buffalo Crushed Stone	Buffalo, NY	X				Air-cooled.
C. J. Langenfelder	Baltimore, MD		X			--
Do.	Braddock, PA		X			--
CSR America	Middletown, OH	X				Air-cooled.
Dunbar Slag Co. Inc.	Wheatland, PA	X		X		Do.
Heckett Co.	Fontana, CA	X				Do.
Do.	Wilton, IA				X	--
Do.	Chicago, IL	X				Air-cooled.
Do.	Sterling, IL				X	--
Do.	East Chicago, IN		X			--
Do.	Indiana Harbor, IN		X			--
Do.	Ashland, KY	X	X			Air-cooled.
Do.	Coalton, KY				X	--
Do.	Newport, KY				X	--
Do.	Owensboro, KY				X	--
Do.	Kansas City, MO				X	--
Do.	Canton, OH		X			--
Do. (Warren Plant)	Warren, OH		X			--
Do.	do.				X	--
Do.	Youngstown, OH				X	--
Do.	Butler, PA				X	--
Do.	Provo, UT	X		X		Air-cooled.
Do.	Seattle, WA				X	--
International Mill Service	Fort Smith, AR				X	--
Do.	Pueblo, CO		X			--
Do.	Claymont, DE				X	--
Do.	Tampa, FL				X	--
Do.	Cartersville, GA				X	--
Do.	Alton, IL				X	--
Do.	Chicago, IL	X			X	Air-cooled.
Do.	Granite City, IL		X			--
Do.	Huntington, IN				X	--
Do.	Laplace, LA				X	--
Do.	Jackson, MI				X	--
Do.	Monroe, MI				X	--
Do.	St. Paul, MN				X	--
Do.	Perth Amboy, NJ				X	--
Do.	Riverton, NJ				X	--
Do.	Marion, OH				X	--
Do.	Middletown, OH		X		X	--
Do.	Mingo Junction, OH		X		X	--
Do.	Sand Springs, OK				X	--
Do.	McMinnville, OR				X	--
Do.	Portland, OR				X	--
Do.	Beaver Falls, PA				X	--
Do.	Burgettstown, PA				X	--
Do.	Coatesville, PA				X	--
Do.	Midland, PA				X	--
Do.	Pricedale, PA		X		X	--

TABLE 3 - Continued
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 1994

Company	Plant location	Slag source				Blast furnace slag type
		Iron blast furnace	Steel			
			Basic oxygen furnace	Open hearth	Electric arc furnace	
International Mill Service-Continued	Reading, PA				X	--
Do.	Georgetown, SC				X	--
Do.	Jackson, TN				X	--
Do.	Beaumont, TX				X	--
Do.	Jewett, TX				X	--
Do.	Longview, TX				X	--
Do.	Midlothian, TX				X	--
Do.	Saukville, WI				X	--
Do.	Weirton, WV		X			--
Koch Minerals	Gary, IN	X				Air-cooled, expanded and granulated.
Do.	Weirton, WV	X				Granulated.
Edward C. Levy Co.	Detroit, MI	X	X		X	Air-cooled and expanded.
The Levy Co. Inc.	Burns Harbor, IN	X	X			Air-cooled.
Do.	East Chicago, IN	X				Do.
Maryland Slag Co.	Sparrows Point, MD	X				Do.
Standard LaFarge Co.	Granite City, IL	X				Do.
Do.	Cleveland, OH	X				Air-cooled and expanded.
Do.	Cuyahoga, OH			X		--
Do.	Lordstown, OH	X		X		Granulated.
Do.	McDonald, OH			X		--
Do.	Mingo Junction, OH	X				Air-cooled.
Do.	Warren, OH	X				Do.
Do.	Youngstown, OH			X		--
Do.	Penn Hills, PA			X		--
Do.	West Aliquippa, PA	X				--
Do. (Brown Reserve)	West Mifflin, PA	X				Air-cooled.
Do. (Duquesne)	do.	X	X	X		Do.
Do.	Weirton, WV	X				Do.
Stein, Inc.	Cleveland, OH		X			--
Do.	Lorain, OH		X			--
United Slag Co.	Rancho Cucamonga, CA				X	--
Vulcan	Alabama City, AL	X				Air-cooled.
Do.	Fairfield, AL	X	X			Do.
Waylite Corp.	Bethlehem, PA	X	X	X		Air-cooled and expanded.

TABLE 4
AIR - COOLED BLAST FURNACE SLAG SOLD OR USED IN THE UNITED STATES, BY USE 1/ 2/

(Thousand metric tons and thousand dollars)

Use	1993		1994	
	Quantity	Value	Quantity	Value
Asphaltic concrete aggregate	2,050	13,100	1,940	12,200
Concrete aggregate	1,000	7,410	1,180	8,540
Concrete products	442	2,250	498	3,120
Fill	1,460	6,410	870	3,030
Glass manufacture	W	W	W	W
Mineral wool	507	3,620	621	4,430
Railroad ballast	157	678	188	867
Road bases	4,380	23,400	4,850	26,500
Roofing, built-up and shingles	43	538	71	946
Sewage treatment	W	W	W	W
Soil conditioning	W	W	W	W
Other 3/	439	4,290	475	2,800
Total	10,500	61,700	10,700	62,400

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Value based on selling price at plant.

3/ Includes ice control, miscellaneous and uses indicated by symbol "W."

TABLE 5
STEEL SLAG SOLD OR USED IN THE UNITED STATES, BY USE 1/ 2/

(Thousand metric tons and thousand dollars)

Use	1993		1994	
	Quantity	Value	Quantity	Value
Asphaltic concrete aggregate	1,090	4,920	1,140	5,000
Fill	905	2,370	1,320	3,750
Railroad ballast	116	323	160	467
Road bases	2,660	8,120	3,170	11,300
Other 3/	1,900	7,130	2,000	6,400
Total	6,670	22,900	7,800	26,900

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes tonnage returned to furnace for charge material. Value based on selling price at plant.

3/ Includes ice control, soil conditioning, and miscellaneous uses.

TABLE 6
SHIPMENTS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 1994, BY METHOD OF TRANSPORTATION 1/

Method of transportation	Quantity (thousand metric tons)
Truck	17,000
Waterway	837
Rail	886
Not transported (used at plant site)	1,360
Total	20,100

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to total shown.

TABLE 7
AVERAGE VALUE PER TON AT THE PLANT FOR IRON AND STEEL SLAG SOLD OR USED IN THE UNITED STATES, BY TYPE

(Dollars per metric ton)

Year	Iron blast furnace slag		Steel slag	Total slag
	Air-cooled	Total iron slag		
1993	5.89	8.40	3.43	6.65
1994	5.84	9.23	3.45	6.99

TABLE 8
AVERAGE SELLING PRICE AND RANGE OF SELLING PRICES AT THE PLANT FOR IRON AND STEEL SLAG IN THE UNITED STATES IN 1994, BY USE

(Dollars per metric ton)

Use	Iron blast furnace slag			
	Air-cooled		Steel slag	
	Average	Range	Average	Range
Asphaltic concrete aggregate	7.24	4.11 - 11.95	4.38	2.12 - 9.49
Cement manufacture	W	W	W	W
Concrete products	6.26	4.07 - 7.99	--	--
Fill	3.48	2.28 - 8.00	2.83	1.29 - 4. 19
Glass manufacture	W	W	W	W
Mineral wool	7.15	5.00 - 9.02	--	--
Railroad ballast	4.61	2.77 - 8.50	2.92	2.42 - 6.55
Road bases	5.46	2.28 - 8.00	3.56	.93 - 11.42
Roofing, builtup and shingles	13.32	6.10 - 69.77	--	--
Sewage treatment	W	W	W	W
Soil conditioning	W	W	W	W
Other	6.51	2.11 - 9.46	3.04	.05 - 4.82

W Withheld to avoid disclosing company proprietary data.

SODA ASH

By Dennis S. Kostick

Soda ash, also known as sodium carbonate, is an important inorganic chemical that is used by many industries for several applications. Two types of soda ash are produced in the world—natural and synthetic. The United States is the world's largest soda ash-producing nation with the world's largest natural deposit of trona, the ore from which soda ash is refined. Because most of the world's output is manufactured, which usually is more expensive to make, U.S. natural soda ash is extremely competitive in world markets.

The world soda ash industry continued to change in 1994 as countries emerged from depressed economic conditions and began to manufacture more glass, chemical, and detergent products, all of which use large quantities of soda ash. Because several small-scale plants were closed in the past 4 years, world capacity declined more than new capacity came on-stream. Most industry analysts would agree that there was surplus capacity beforehand and current levels are more realistic for short-term demand requirements. A few foreign soda ash consumers or foreign glass manufacturers have already secured a long-term position in the U.S. soda ash industry through joint ventures or total acquisitions. This trend will inevitably continue throughout the remainder of this century.

Production

Soda ash production data are collected by the U.S. Bureau of Mines (USBM) from monthly, quarterly, and annual voluntary surveys of U.S. soda ash operations. Of the six soda ash operations to which a survey request was sent, all responded, representing 100% of the total production data shown in this report.

U.S. soda ash production in 1994 was the second highest year as output reached 9.32 million metric tons, up 4% over that of the previous year. The record high was set in 1992. With domestic nameplate capacity exceeding 11 million tons, the industry operated at 85% of capacity utilization during 1994, with some companies operating at, or near nameplate capacities while others produced below their design ratings. According to data surveyed by the USBM, total Wyoming trona production from the five producers was 14.6 million tons, which agrees with the total collected by the office of the Wyoming State Inspector of Mines. In its report[1], FMC Wyoming Corp. produced 4.05 million tons, General Chemical Corp. 3.69 million tons, Rhône-Poulenc Basic Chemicals Co. 2.88 million tons, Solvay Minerals Co. 3.14 million tons, and Tg Soda Ash, Inc., 2.32 million tons.

FMC announced plans to expand its Wyoming soda ash facility by 635,000 metric tons, thereby raising total nameplate capacity to 3.22 million tons by 1997. The $140 million project involves new technology and a tailings disposal concept to slurry mine waste to abandoned underground sections of the mine. Removal of the spent tailings reduces surface containment costs, pond maintenance expenses, and promotes environment remediation.[2]

White River Nahcolite Minerals, which was a joint venture formed in 1992 between NaTec Resources, Inc. (with CRS Sirrine Inc. as a partner) and North American Chemical Co. continued to solution mine nahcolite (natural sodium bicarbonate) near Rifle in the Piceance Creek Basin of Colorado. However, in June 1994, the relationship became strained as NaTec filed a lawsuit against North American citing the latter failed to pay $625,000 as stipulated in their agreement. North American alleged that NaTec had failed to demonstrate that the facility could produce at its designed annual capacity of 96,000 tons as required by the joint-venture agreement. NaTec alleged that North American prevented it from operating at full capacity by refusing to use additional processing equipment at the site and to implement process modifications.[3] CRSS refused to invest any additional money into the venture and sold its part of NaTec for $15 million ($12 million in cash and $3 million in a promissory note) to AmerAlia Inc. In November, NaTec announced that it would sell 80% of its assets in White River Nahcolite Minerals to North American Chemical for $10 million ($6 million in cash and $4 million in non-interest bearing promissory note with a 5-year limit). The sale resolved the litigation between the two that existed since June.[4]

In December, Natrona Resources Inc. announced plans to begin feasibility studies on constructing a soda ash and sodium bicarbonate facility in the Piceance Creek Basin of northwest Colorado. The planned venture would solution mine nahcolite (natural sodium bicarbonate) and process it into marketable sodium products that would compete with material produced in Wyoming and California.[5]

Consumption and Uses

Reported consumption data by end use are collected quarterly from the marketing and sales departments of each company within the industry. Every effort has been made to categorize company sales with the intended end-use sector. Quarterly reports are often revised in subsequent quarters because of customer reclassifications, etc. Reported consumption data have been collected quarterly since 1987; prior years were estimated by the commodity specialist based on contacts with members of the industry and establishing benchmarks by using the Bureau of the Census' Census of Manufacturers report that is done every 5 years (i.e. 1977, 1982, 1987, etc.) Intervening years were extrapolated based on knowledge of rising or falling industry trends within that end-use sector. Because all six U.S. soda ash companies respond to the quarterly survey, the data represents 100% of the total reported consumption data found in this report. Reported consumption data and apparent consumption data do not necessarily correspond because of dissimilar sources of export data. The quarterly reported consumption survey are exports as declared by the industry; apparent consumption export data are those as collected by the Bureau of the Census, including any adjustments. In

1994, the distribution of domestic soda ash sales by end-use sector was glass, 51% (of which container was 28%, flat glass, 15%, and fiberglass and specialty glass, 4% each); chemicals, 22%; soap and detergents, 13%; distributors, 5%; miscellaneous uses, 3%; and pulp and paper, water treatment, and flue gas desulfurization, 2% each.

Although domestic consumption was slow during the first half of the year, third and fourth quarter sales of soda ash rose, especially in the flat glass and fiberglass sectors. These two sectors increased because of greater demand for glass products for the automotive and construction industries, both of which reflect the status of the national economy. Soda ash sold for pulp and paper use increased as well due to the rise in the price and the reduced availability of electrolytic caustic soda, which often is preferred for pulp digestion because of its stronger alkalinity. By yearend, caustic soda was in short supply in the West which caused the three manufacturers of chemical caustic soda in Wyoming (FMC Wyoming Corp. with a 59,000 ton per year plant, Solvay Minerals Co. with a 68,000 tons per year plant, and Tg Soda Ash, Inc. with a 91,000 tons per year plant) to restart their chemical caustic plants. U.S. apparent consumption in 1994 was 6.24 million tons, down from 6.35 million tons in 1993.

Stocks

Yearend stocks of dense soda ash in domestic plant silos, warehouses, terminals, and on teamtracks amounted to 203,000 tons. Producers indicate that a potential supply problem could exist when inventories fall below 180,000 tons. Most consumers of soda ash do not have adequate storage facilities to accommodate large quantities of soda ash and must rely on suppliers to provide the material on a timely basis. A large domestic consumer would have the capability to store no more than 2 weeks of product at its site. The majority of the U.S. soda ash producers that had been shipping to Europe have several foreign warehouses for product storage. These warehouses serve the needs of most foreign soda ash consumers that purchase U.S. soda ash. In addition, the industry's export association, the American Natural Soda Ash Corp. (ANSAC), has arrangements to store soda ash prior to arrival of ships at the ports.

Markets and Prices

The U.S. industry in September led off with a $3 per ton increase in the off-list price of soda ash effective January 1995. As domestic consumption and exports increased in late 1994, the industry announced another price hike of $5 per ton in an attempt to firm up contracts for the next year.[6] There also was an effort to lower the Wyoming list price from $98 per ton to $88 per ton; the move, however, was not universally accepted and the price remained at $98 per ton. The final 1994 annual average value of bulk dense soda ash sold on long-term contract, discounts, spot price, and export, was $70.44 per short ton, which was below the $74.34 per ton reported for 1993.

Foreign Trade

Import and export statistics are obtained from the U.S. Department of Commerce, Bureau of the Census, and analyzed using trade data provided by the Journal of Commerce's Port Import Export Reporting Service (PIERS). The export data collected by the Bureau of the Census may not correspond to the export data provided by the six soda ash producers in the quarterly survey of soda ash sales or the PIERS data. The discrepancy between the export data sets is because Census data report the transaction on the date the cargo physically left from the U.S. port whereas soda ash producers consider a shipment as exported when it leaves the plant. The overland transit time between the plant and port and any export inventory carryover, both in domestic and foreign warehouses or teamtracks, are the major reasons for the difference between the export data.

U.S. soda ash exports rebounded in the fourth quarter as ANSAC shipped at record levels, achieving an all time high of 3.23 million tons even with reduced exports to Europe. Many global economies began to recover, especially in the flat glass markets. The international rise in caustic soda prices also prompted many caustic customers throughout the world to convert to soda ash. The percent distribution of U.S. soda ash exports to 50 nations in 1994, on a regional basis, was Asia, 49%; South America, 19%; North America, 15%; Europe, 9%; Africa and the Middle East, 3% each; and Central America and Oceania, 1% each. The source of trade statistics is the U.S. Department of Commerce's Bureau of the Census; however, because of some erroneous transactions, the data included in this report were adjusted by the USBM using data and information from the Journal of Commerce and industry sources.

Despite that the European Union (EU) Commission did not issue its final ruling on the antidumping investigation it conducted against the U.S. soda ash industry, exports to Europe continued.[7] North American Chemical Co. shipped about 84,000 tons, FMC 47,000 tons, Asahi (Solvay Minerals' partner) 28,000 tons, General Chemical 22,000 tons, and Rhône-Poulenc 7,000 tons.[8] Texasgulf did not export any soda ash to Europe in 1994 but was the major supplier in 1992 and 1993. In addition, ANSAC exported about 66,000 tons through Croatia and Slovenia to Hungary for Guardian Industries float glass plant in Hungary.

With the removal of the antidumping duties on light soda ash on May 15, 1994, Bulgaria and Poland exported about 400,000 tons to western Europe with prices reportedly about 10% below the European price.[9] Although the EU was requested to investigate dumping by the East Europeans, the Commission was reluctant to initiate any action because of the sensitive political situation between the two parts of Europe.[10] With the changing political and economic conditions in eastern Europe, synthetic soda ash producers have operated substantially below capacity since with the loss of subsidized energy. The product also is of poorer quality than western standards except some of the soda ash produced in Bulgaria and from one Polish plant. This was the material being shipped to western Europe at lower prices.

World Review

Botswana.—The natural soda ash operation in Botswana in late 1994 announced it planned to upgrade the quality of its product and expand market share. The company, Soda Ash Botswana, which is a joint venture among African Explosives and Chemical Industries, Anglo American, and the Botswana Government, only has been operating at about one-half of its 300,000 ton-per-year capacity because of poor demand in the markets it exports into. The Republic of South Africa represents 92% of soda ash demand in southern Africa with Zambia and Zimbabwe accounting for the remainder. Approximately 45% of the soda ash was used in glass container and flat glass manufacture.[11]

France.—In May, Rhône-Poulenc of France and Akzo Nobel of the Netherlands, announced plans to form a new joint venture effective January 1995 with Rhône-Poulenc holding 67% of the partnership and Akzo the remaining 33%. The proposed union would result in a stronger and more competitive company that would have about 1 million tons of combined capacity at Nancy, France and Delfzijl, Netherlands and annual sales of more than one billion French francs ($175 million). The venture would take advantage of Akzo's market strength in the Benelux region of Europe and Rhône-Poulenc's in France. Although the Green River, WY, plant is not part of the joint venture, natural soda ash could be exported to supply Europe. In addition, Rhône-Poulenc improved its position through its long-term contract to provide Chemische Fabrik Kalk (CFK) following the closure in late 1993 of CFK's Cologne, Germany plant, which had an annual capacity of 300,000 tons.[12]

In November, however, both companies determined they would suspend their formal negotiations to merge, citing neither could ascertain the value of the assets each company planned to contribute to the partnership. The decision does not rule out the possibility of reassessing the proposed merger in the future. Both companies remained committed to their soda ash businesses. For example, Rhône-Poulenc still planned to acquire the synthetic soda ash plants in Poland, which wanted to privatize them.[13]

Germany.—Lars Christensen Chemicals of Denmark completed its $234 million project to upgrade its synthetic soda ash plant in Strassfurt, Germany in October. It converted one of the two units of the plant from 250,000 tons per year light soda ash to 200,000 tons per year of dense soda ash. The changeover to dense material was in response to the growing demand for dense soda ash for glass manufacture. The second unit produces 100,000 tons of dense product annually and 30,000 tons of light soda ash. The company acquired the facility from the Treuhandanstalt, the former East German government, in 1991. Although the plant is small compared with world standards, it was important to invest in upgrading this facility in eastern Germany to continue to provide employment and generate revenue for the local economy.[14]

India.—India has become a major soda ash producing nation with most of its output destined for internal consumption by the glass and detergent industries. Nirma Ltd. of Ahmedabad, which is a large Indian detergent manufacturer, announced plans to construct a 1,200 tons-per-day synthetic soda ash plant in Gujarat. An earlier plan was to build the plant near Junagadh on the Saurashtra coast and use processing technology from Asahi Chemicals of Japan.[15]

Kenya.—In early 1994, Brunner Mond & Co., Ltd. of England announced plans to expand natural soda ash annual production capacity at Lake Magadi in Kenya by 50,000 tons. The $1 million project would raise total capacity to 300,000 tons per year. Because about 90% of production is exported through the port of Mombassa, plant output had been limited due to inadequate transportation arrangements.[16] The company is negotiating to take over the rail link to the port which would improve overall efficiency and expand exports. Presently, Lake Magadi soda ash is shipped to markets in neighboring African countries, the Middle East, and the Far East; all of which have growing soda ash demand. Brunner Mond anticipates to expand capacity to 1 million tons during the next 15 years.

Brunner Mond's parent corporation, Brunner Mond Holdings, and Penrice Ltd. of Australia, which owns 5% of Brunner Mond Holdings, initiated a study to evaluate the benefits of a formal merger of both companies for financial and strategic interests. The merger was to occur by yearend; however, a delay that would carry over into 1995 was necessary so Brunner Mond could restructure its estimated $10 million debt. In 1991, the two companies purchased the soda ash plants in England and Kenya for $133 million from Imperial Chemical Industries.[17]

Outlook

Demand for U.S. produced soda ash in 1995 should continue to be strong, especially in the export market. With the adverse ruling by the EU Commission, soda ash exports to Europe are forecast to be less than 100,000 tons. Some of this will be carryover sales from previous year's contract commitments. With no antidumping duty, Tg may be in a more favorable position to negotiate contracts with European customers for 1996. Domestic soda ash consumption should continue to be stable in the flat glass and fiberglass sectors as the automotive and construction industries remain robust. The caustic soda producers will strive for increased export sales that may create a domestic shortage leading to escalating prices. Should this occur, caustic soda customers may turn toward the soda ash suppliers to satisfy their sodium oxide requirements. The annual growth rate for domestic soda ash consumption is forecast to grow at no more than 1.5% for the short term; however, the total soda ash demand growth rate including exports is forecast to grow between 2% and 2.5% annually throughout this decade.

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[3] Chemical Marketing Reporter. Bicarb Partners Clash. June 13, 1994, v. 245, No. 24, p. 5.

[4] Press Release. NaTec Resources. NaTec Resources Announces Letter of Intent For Sale of Substantially All the Assets to North American Chemical Company, Nov. 18, 1994.

[5] Press Release. Natrona Resources Inc. Natrona Awards Contract to Raytheon For Colorado's First Soda Ash Plant. Dec. 28, 1994.

[6] Chemical Marketing Reporter. Soda Ash. Dec. 5, 1994, v. 246, No. 23, p. 22.

[7] Chemical Marketing Reporter. EU Takes Tough Stand On Dumping, Jan. 16, 1995, v. 247, No. 3, p. 9.

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TABLE 1
SALIENT SODA ASH STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Production 2/	9,160	9,010	9,380	8,960	9,320
Value 2/	$836,000	$836,000	$837,000	$734,000	$724,000
Production, Wyoming trona	14,700	14,700	14,900	14,500	14,600
Exports	2,390	2,730	2,960	2,800	3,230
Value	$347,000	$409,000	$434,000	$376,000	$406,000
Imports for consumption	146	134	72	89	79
Value	$20,500	$21,300	$12,800	$17,100	$12,100
Stocks, Dec. 31: Producers'	287	234	371	274	203
Consumption:					
Apparent	6,840	6,460	6,360	6,350	6,240
Reported	6,530	6,280	6,320	6,280 r/	6,260
World: Production	32,000	31,200 r/	31,100 r/	30,500 r/	30,400 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits.

2/ Natural only, soda liquors and purge liquors converted to soda ash equivalent are as follows: 1990, 112,000 tons; 1991, 117,000 tons; 1992, 121,000 tons; 1993, 85,000 tons; and 1994, 91,600.

TABLE 2
U.S. PRODUCERS OF SODA ASH IN 1994

(Million short tons, unless otherwise noted)

Company	Plant nameplate capacity	Plant location	Source of sodium carbonate
FMC Wyoming Corp.	2.85	Green River, WY	Underground trona.
General Chemical (Soda Ash) Partners 1/	2.40	do.	Do.
North American Chemical Co. 2/	1.30	Trona, CA	Dry lake brine.
Rhone Poulenc of Wyoming, L.P. 3/	2.30	Green River, WY	Underground trona.
Solvay Minerals Inc. 4/	2.00	do.	Do.
Tg Soda Ash Inc. 5/	1.30	Granger, WY	Do.
Total	12.15		
Total million metric tons	11.02		

1/ A joint venture between General Chemical Corp. (51%), Australian Consolidated Industries International (ACI-25%), and TOSOH Wyoming Inc. of Japan (24%), which purchased part of ACI's share June 1992.

2/ Oriental Chemical Industries of Korea as a partner had 27% equity share, but was reduced to about 7% in 1993.

3/ Joint venture between Rhone-Poulenc Basic Chemicals Co. of France (51%) and Union Pacific Resources Co. (49%).

4/ Operation is a joint venture with Solvay S.A. of Belgium (80%) and Asahi Glass Co. of Japan (20%), which became a partner in Feb. 1990.

5/ Owned by Texasgulf Inc., subsidiary of Societe Nationale Elf Aquitaine of France (100%).

TABLE 3
REPORTED CONSUMPTION OF SODA ASH IN THE UNITED STATES, BY END USE 1/

(Metric tons)

SIC Code	End use	1993 Total	1994 First Quarter	1994 Second Quarter	1994 Third Quarter	1994 Fourth Quarter	1994 Total
32	Glass:						
3221	Container	1,790,000	447,000	458,000	451,000	426,000	1,780,000
3211	Flat	869,000	215,000	226,000	237,000	248,000	926,000
3296	Fiber	220,000	55,400	52,500	55,600	57,000	220,000
3229	Other	215,000	48,800	51,900	60,500	59,300	220,000
	Total:	3,100,000	765,000	789,000	804,000	790,000	3,150,000
281	Chemicals	1,480,000	328,000	335,000	344,000	367,000	1,370,000
284	Soaps and detergents	806,000	211,000	201,000	212,000	210,000	834,000
26	Pulp and paper	139,000	25,600	24,900	44,800	49,700	145,000
2899	Water treatment 2/	116,000	26,500	25,600	25,700	24,800	103,000
	Fluegas desulfurization	151,000 r/	43,500	29,300	33,600	32,100	138,000
	Distributors	337,000	81,700	77,300	77,400	76,300	313,000
	Other	163,000 r/	39,500	43,500	59,000	63,900	206,000
	Imports 3/	88,900	19,500	21,700	21,700	15,600	78,700
	Total Domestic Consumption 4/	6,280,000 r/	1,520,000	1,530,000	1,600,000	1,610,000	6,260,000
	Exports 5/	2,840,000	699,000	835,000	749,000	985,000	3,270,000
	Canada	116,000	31,300	39,600	29,100	42,600	143,000
	Total Industry Sales 6/	9,130,000 r/	2,220,000	2,360,000	2,350,000	2,600,000	9,530,000
	Total Sales from Plants	8,760,000	2,200,000	2,270,000	2,270,000	2,500,000	9,230,000
	Total Production	8,960,000	2,190,000	2,270,000	2,320,000	2,540,000	9,320,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes soda ash equivalent from soda liquors and purge liquors sold to powerplants for water treatment. Sales of mine water are excluded.

3/ Data are from the Bureau of the Census and may vary from the quantity reported by the producer and/or importer. Actual imports are proprietary data but have been distributed into appropriate end-use categories and included in "Total domestic reported consumption."

4/ Reported consumption data do not agree with apparent consumption data shown in table 1 because of dissimilar sources of export data. The data vary because of different reporting periods, overland transit time between plant and port, and carryover export inventory.

5/ As reported by producers. Includes Canada. Data may not necessarily agree with that reported by the Bureau of Census for the same periods.

6/ Represents soda ash from domestic origin (production and inventory changes) and imports, and for exports. Includes soda ash sold by coproducers and distibuted by purchasers into appropriate end use categories.

TABLE 4
SODA ASH YEAREND PRICES

		1993	1994
Sodium carbonate (soda ash):			
Dense, 58%, Na2O 100-pounds, paper bags, carlot, works, f.o.b.	per short ton	$146.00	$146.00
Bulk, carlot, same basis tons	do.	98.00	98.00
Light 58%, 100-pounds, paper bags, carlot same basis	do.	151.00	151.00
Bulk, carlot, same basis tons	do.	103.00	103.00

Sources: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 245. No. 1, Dec. 31, 1993, p.30. and V. 247. No. 1, Dec. 30, 1994, p.32.

TABLE 5
REGIONAL DISTRIBUTION OF U.S. SODA ASH EXPORTS, BY CUSTOMS DISTRICTS, IN 1994 1/

(Metric tons)

Customs districts	North America	Central America	South America	Caribbean	Europe	Middle East	Africa	Asia	Oceania	Total	Percent of total
Atlantic:											
Baltimore, MD	--	--	--	--	11	--	86	--	--	97	--
Miami, FL	--	16	203	74	--	--	--	--	--	293	--
New York, NY	--	--	19	--	8,110	(2/)	--	--	--	8,130	--
Washington, DC	--	--	--	--	(2/)	--	--	--	--	(2/)	--
Gulf:											
Houston-Galveston, TX	14,000	--	--	--	16,700	--	--	--	--	30,700	1%
New Orleans, LA	--	95	--	26	--	--	--	--	--	121	--
Port Arthur, TX	--	--	215,000	12,500	44,100	27,000	--	--	--	299,000	9%
Pacific:											
Columbia-Snake River	--	15,300	116,000	--	104,000	55,800	77,400	1,570,000	32,100	1,970,000	61%
Los Angeles, CA	--	--	6,050	--	23,600	5	--	142	241	30,000	1%
San Diego, CA	11,000	11,200	271,000	--	99,100	8,500	6,120	16,100	--	423,000	13%
San Francisco, CA	--	--	--	--	--	--	--	--	862	862	--
Seattle, WA	10,200	--	--	--	--	--	--	412	--	10,600	--
North Central:											
Chicago, IL	--	--	--	--	42	--	--	--	--	42	--
Detroit, MI	77,300	--	--	--	250	--	--	--	--	77,600	2%
Great Falls, MT	28,800	--	--	--	--	--	--	--	--	28,800	1%
Pembina, ND	6,580	--	--	--	--	--	--	--	--	6,580	--
Northeast:											
Buffalo, NY	3,990	--	--	--	187	--	--	--	--	4,180	--
Ogdensburg, NY	381	--	--	--	--	--	--	--	--	381	--
Portland, ME	167	--	--	--	--	--	--	--	--	167	--
Southwest:											
El Paso, TX	4,910	--	--	--	--	--	--	--	--	4,910	--
Laredo, TX	313,000	--	--	--	--	--	--	--	--	313,000	10%
Nogales, AZ	16	--	--	--	--	--	--	--	--	16	--
Other:											
San Juan, PR	--	--	--	281	--	--	--	--	--	281	--
Unknown:	22,200	--	--	--	--	--	--	--	--	22,200	1%
Total	493,000	26,600	609,000	12,900	297,000	91,400	83,600	1,590,000	33,200	3,230,000	100%
Percent of total	15%	1%	19%	--	9%	3%	3%	49%	1%	100%	--

1/ Data rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census as adjusted by the U. S. Bureau of Mines using trade data and information from the Journal of Commerce.

TABLE 6
U.S. EXPORTS OF SODA ASH, BY COUNTRY 1/

(Metric tons)

Country	1993	1994
Antigua	- -	18
Argentina	96,600	109,000
Aruba	- -	14
Australia	65,200	25,800
Belgium	149,000	129,000
Bolivia	1,650	5,850
Brazil	88,800	167,000
Canada	120,000	150,000
Chile	59,200	59,400
China	59,100	92,200
Colombia	74,200	68,200
Costa Rica	8,100	4,850
Croatia 2/	51,900	63,300
Dominican Republic	- -	307
Ecuador	9,550	9,770
El Salvador	3,080	4,340
France	19,100	13,500
Gabon	(3/)	- -
Germany	21	- -
Guatemala	18,200	14,800
Hong Kong	909	65
Indonesia	237,000	284,000
Iran	20,000	- -
Ireland	- -	42
Israel	8,560	35,500
Italy	37,800	47,200
Jamaica	8,000	3,950
Japan	353,000	340,000
Korea, Republic of	237,000	341,000
Malaysia	68,600	57,500
Marshall Islands	3	- -
Mexico	190,000	343,000
Netherlands	80,300	- -
Netherlands Antilles	22	15
New Zealand	7,540	7,360
Panama	1,760	2,600
Paraguay	- -	301
Peru	13,800	16,700
Philippines	85,600	76,000
Poland	50	30,200
Romania	20	- -
Russia	- -	1,700
Saudi Arabia	32,600	55,800
Sierra Leone	29	86
Singapore	13,000	13,000
Slovenia 2/	13,700	12,000
South Africa, Republic of	65,000	83,500
Spain	70,500	- -
Sweden	17,700	2
Taiwan	123,000	188,000
Thailand	105,000	195,000
Trinidad and Tobago	8,510	8,560
United Kingdom	5,000	2
Uruguay	3,670	8,540
Venezuela	167,000	164,000
Yemen	1	- -
Total	2,800,000	3,230,000

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Formerly part of Yugoslavia.
3/ Less than 1/2 unit.

Source: Bureau of the Census and Statistics Canada, as adjusted by the U. S. Bureau of Mines.

TABLE 7
U. S. PRODUCTION OF SODIUM COMPOUNDS, BY MONTH, IN 1994 1/

(Metric tons)

	Soda Ash	Soda Liquors	Wyoming Trona
January	714,000	6,620	1,290,000
February	691,000	6,550	1,150,000
March	786,000	8,680	1,270,000
April	734,000	6,490	1,120,000
May	791,000	7,680	1,210,000
June	746,000	8,120	1,110,000
July	799,000	7,810	1,160,000
August	741,000	10,800	1,170,000
September	775,000	7,230	1,170,000
October	853,000	7,840	1,250,000
November	834,000	6,790	1,340,000
December	858,000	6,980	1,350,000
Total	9,320,000	91,600	14,600,000

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 8
SODA ASH: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons)

Country	1990	1991	1992	1993	1994e/
Albania e/	27	16	(3/)	--	--
Australia e/	300	300	300	300	300
Austria e/	150	150	150	150	150
Belgium e/ 4/	375	380	375	300	--
Bosnia and Herzegovina e/ 5/	XX	XX	25	20	15
Botswana	--	62	124	126 r/	140
Brazil e/	200	200	200	200	200
Bulgaria	1,050	893	517 r/	550 r/ e/	550
Canada e/	315	310	305	305	300
China e/	3,750	3,940	4,500	5,270	5,680
Colombia e/	121 6/	121	121	121	121
Czechoslovakia e/ 7/	104 6/	104	100	XX	XX
Egypt	52	52	51 e/	51 e/	51
France	1,180	1,140	1,100	1,000 e/	1,200
Germany:					
Eastern states e/	850	XX	XX	XX	XX
Western states	1,440	XX	XX	XX	XX
Total e/	2,290	1,950	1,640	1,590 r/	1,600
India e/	1,400	1,500	1,500	1,500	1,500
Italy e/	610	600	600	500	500
Japan	1,130	1,100	1,060 r/	1,060 r/	1,060
Kenya e/ 8/	244 6/	245	245	245	245
Korea, Republic of e/	280	300	300	310	310
Mexico e/ 9/	449 6/	449	440	440 r/	280
Netherlands e/	400	400	400	400	400
Pakistan e/	135	147	146	186 r/ 6/	180
Poland	968	962	929	950 e/	950
Portugal e/	150	150	150	150	150
Romania	632	471 r/	452 r/	450 r/ e/	450
Russia e/	XX	XX	3,000	2,500	2,000
Spain e/	527 6/	500	500	500	500
Taiwan	120 e/	109	91	100 e/	100
Turkey e/	385	385	385	385	385
U.S.S.R. 10/	4,360	4,100 e/	XX	XX	XX
Ukraine e/	XX	XX	1,000	900	800
United Kingdom e/	1,000	1,000	1,000	1,000	1,000
United States 8/	9,160	9,000	9,380	8,960	9,320 6/
Yugoslavia 5/ 11/	173	140 e/	XX	XX	XX
Total	32,000	31,200 /r	31,100 /r	30,500 /r	30,400

e/Estimated. r/Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three sigificant digits; data may not add to totals shown.

2/ Table includes data available through Apr. 20, 1995. Synthetic unless otherwise specified.

3/ Less than 1/2 unit. Plant at Vlora reportedly closed in 1993.

4/ Plant at Couillet closed by yearend 1993.

5/ All production in Yugoslavia for 1990-91 came from Bosnia and Herzegovina.

6/ Reported figure.

7/ Dissolved on Dec. 31, 1992.

8/ Natural only.

9/ Includes natural and synthetic. Estimated production of natural soda ash, in metric tons, was as follows: 1990--190,000; 1991--190,000; 1992--160,000 ; and 1993--160,000 (revised). Natural soda ash operation closed in Aug. 1993.

10/ Dissolved in Dec. 1991.

11/ Dissolved in Apr. 1992.

SODIUM SULFATE

By Dennis S. Kostick

Sodium sulfate is produced from naturally occurring brines or crystalline mineral sources and as a byproduct from various chemical processes. It is used to make many consumer products used by virtually everyone, such as powdered laundry detergents, brown paper bags, textiles, and glass. Based on an annual survey of the nation's top 50 organic and inorganic chemicals produced, sodium sulfate had traditionally ranked about 47th in terms of production volume; however, in 1994 for the first time sodium sulfate failed to appear on this top 50 chemical list.[1]

Production

U.S. production and inventory data for natural sodium sulfate are obtained by the U.S. Bureau of Mines from monthly and annual surveys of domestic operations. All producers of natural sodium sulfate responded to the canvass, representing 100% of the natural sodium sulfate data used in this report.

Synthetic sodium sulfate data were collected by the U.S. Department of Commerce, Bureau of the Census, from quarterly and annual surveys of companies engaged in recovering and selling byproduct sodium sulfate. The information was published in the Current Industrial Reports, Inorganic Chemicals, MQ28A (quarterly) and MA28A (annual). Any revised Census Bureau data have been included in this report using the most recent Census Bureau statistics. These data are aggregated with U.S. Bureau of Mines natural sodium sulfate data and included in several tables. [(See table 1.)]

Production of natural and synthetic sodium sulfate declined 14% in 1994. The total sodium sulfate industry operated at 63% of combined nameplate capacity, which was 738,000 metric tons. Producers of natural sodium sulfate, which usually is a high-purity product, will encounter competition from battery recycling companies that plan to upgrade their recovered sodium sulfate material by removing heavy metals and other contaminants that would have prevented them from selling into the high purity markets. These battery recyclers were forced to improve the quality of their byproduct sodium sulfate because environmental regulations became more strict, thereby preventing them from disposing of the material to landfills or underground injection disposal. The Doe Run Co. of Boss, MO, is one company already in business recovering sodium sulfate from battery recycling. [(See table 2).]

Two new battery recycling plants, RSR Corp. of Scotchtown, NY, and GNB Inc., of Columbus, GA, will have high-purity sodium sulfate production capacities reported to be between 20,000 tons and 30,000 tons each. This material is suitable for the detergent industry, which requires a very white, high specification sodium sulfate product. GNB planned to be in operation in 1995, and RSR planned to be onstream in 1996. Another company, Schuilkill Metals, reportedly also intends to recover sodium sulfate at its plant in Baton Rouge, LA.[2] Because this plant will be located near Elf Atochem's natural sodium sulfate operation at Seagraves, TX, Schuilkill will be competing in Atochem's southern and southeast markets.

Concern about the environment has prompted other companies, such as Occidental Chemical Corp., to investigate ways to also upgrade their sodium sulfate. Occidental's chemical plant at Castle Hayne, NC, recovers sodium sulfate but the final product contains some residual chrome compounds that make it unsuitable for sale to markets that demand high-purity product. For this reason, Occidental reportedly planned install a new filtraton system to upgrade one-half of its sodium sulfate output to produce a new high-purity material. Presently, the plant has an annual production capacity of 120,000 tons.[3] The extra availability of high-purity sodium sulfate from byproduct operations will have an adverse affect on the natural sodium sulfate industry, which has always had to price its material based on that of the byproduct. This was part of the reason why Great Salt Lake Minerals Corp. of Ogden, UT, closed its natural sodium sulfate facility in 1993, leaving only two other companies to produce from natural sources.

Consumption and Uses

Apparent consumption of total sodium sulfate declined 3% in 1994 from that of the previous year, based on revised 1993 Census Bureau production data that affected apparent consumption calculations. The estimated distribution of sodium sulfate by end use in 1994 was detergents, 40%; pulp and paper, 20%; textiles, 19%; carpet fresheners and glass, 5% each; and miscellaneous, 11%.[4]

Reduced consumption of saltcake by the pulp and paper industry contributed to part of this decline. Of the 120 kraft pulp and paper mills in the United States, only about 12 continue to use sodium sulfate in the Kraft pulping process. These mills have switched to using chlorine dioxide for the bleaching process that generates its own byproduct sodium sulfate. Pulp mills have converted to oxygen-based chlorine dioxide because of environmental problems associated with chlorine-based bleaching agents, which have been the traditional bleaching compounds used.

The major use of sodium sulfate is as an inert filler with a brilliant whiteness that provides bulk in powdered laundry detergents. The growth of superconcentrated liquid detergents and compact detergents has adversely affected the demand for powdered products. Detergent manufacturers have switched some of their products to powdered formulations, primarily for the export market to certain developing nations that have growing demand for powdered detergents that are less expensive than the liquid alternatives.

The textile industry is another domestic markets that consumes sodium sulfate. In the dyeing process, sodium sulfate is blended with dyes to standardize the concentration of the dyes. Consumption of sodium sulfate by the textile industry reportedly declined but market observers were optimistic that demand should improve because the fashion industry was emphasizing more dark cotton apparel, which uses more sodium sulfate than lighter colored ware. Foreign textile manufacturers, particularly those in China and Mexico, are importing sodium sulfate to meet demand requirements.

Although natural sodium sulfate had been the preferred choice by the glass industry, consumption of byproduct material by glass manufacturers reportedly has increased. The miscellaneous uses of sodium sulfate include ceramics, chemicals (potassium sulfate, sodium hyposulfite, sodium sulfide, sodium silicate, and sodium aluminum sulfate), feed supplements, printing inks, sulfonated oils, veterinary medicines, and viscose sponges.

Foreign Trade

Imports of crude and anhydrous sodium sulfate decreased 14% in 1994, primarily from Canada and Mexico. The average c.i.f. value remained virtually the same--$82.63 per ton in 1994 and $83.44 per ton in 1993. Imports of crude saltcake, which is a low-purity product generally preferred by the pulp and paper industry, represented about 57% of total imports.

Exports declined 27% in 1994. In terms of volume of exports in decreasing order, Canada, Australia, Guatemala, Colombia, the Republic of Korea, and Mexico were the major buyers of U.S. sodium sulfate. (See tables 4 and 5.)

World Review

Total world sodium sulfate production declined for the fourth consecutive year. Approximately 59% of world sodium sulfate output in 1994 was from natural sources. The United States ranked fourth in 1994 in production of natural sodium sulfate and third in synthetic output. (See table 6.)

Canada.—In July 1994, Ormiston Mining and Smelting Co., Ltd., of Ormiston, Saskatchewan announced plans to close because of declining sales to North American markets. However, the plant which had an annual production capacity of 50,000 tons, was still in operation by yearend. Decreased demand also caused other Canadian sodium sulfate producers to operate at reduced capacities. Saskatchewan Minerals, which exports about 70% of its product to the United States, reportedly operated at 70% of capacity while others were at 50%.[5]

Turkey.—Plans to construct a potassium nitrate and sodium sulfate facility were announced. Dead Sea Works and a Turkish chemical company will share the ownership and will each provide the engineering and construction capital. Israel Chemicals will provide the technology for the potassium nitrate plant.[6]

Outlook

Domestic consumption of total sodium sulfate is forecast to remain flat or decline. There will be occasional small surges in demand in certain categories but not enough to make significant changes in growth trends. One positive area for increased sodium sulfate consumption is in the carpet cleaning sector. Carpet freshener products, which have a sodium sulfate content of up to 85%, appears to be a growing market that will benefit the sodium sulfate industry.

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[1] Chemical and Engineering News. Production of Top 50 Chemicals Increased Substantially in 1994. Apr. 10, 1995, V. 73, No. 15, p. 17.

[2] Chemical Marketing Reporter. Natural Sodium Sulfate Squeeze Gets Tighter. Dec. 26, 1994, V. 246, No. 26, p. 5.

[3] ———Sodium Sulfate Pressure Rises. Aug. 15, 1994, V. 246, No. 7, p. 7.

[4] Sodium Sulfate. Chemical Products Synopsis, Mar. 1995, Mannsville Chemical Products Corp.

[5] Work cited in footnote 2.

[6] European Chemical News. In Brief. Apr. 25, 1994, V. 61, No. 1615, p

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Soda Ash and Sodium Sulfate, Ch. in 1985 Mineral Facts and Problems.

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Sodium Sulfate in Ceramic Bulletin, annual commodity review.

Sodium Sulfate Deposits, Industrial Minerals and Rocks, Society of Mining Engineers, 6th ed., 1994.

Sodium Sulfate in Mining Engineering, annual commodity review.

TABLE 1
SALIENT SODIUM SULFATE STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Production, natural	349	354	337	327 r/	298
Production, synthetic	364	366	216 r/	210 r/	165
Synthetic and natural:					
Low Purity (99% or less)	345	367	345 r/	320	W
High Purity	368	353	207 r/	217	W
Total 2/	713	720	552 r/	537 r/	463
Value 3/	$64,200	$62,900	$50,800 r/	$41,100 r/	$37,600
Per ton	$90.10	$87.34	$91.79	$76.53	$81.25
Exports	62	103	155	89	65
Value	$6,700	$11,500	$11,900	$8,540	$7,020
Imports for consumption	162	157	158	163	190
Value	$13,200	$13,800	$13,400	$13,600	$15,700
Stocks, Dec. 31: Producers	39	35	47	42	34
Apparent consumption	798	778	544 r/	616 r/	596
World: Production	5,040 r/	4,720 r/	4,100 r/	4,000 r/	3,860 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes natural and synthetic. Total production data for synthetic sodium sulfate, obtained from the Bureau of the Census, were revised in Feb. 1995 MQ28A Inorganic Chemicals, Current Industrial Report.

3/ The value for synthetic sodium sulfate is based upon the average value for natural sodium sulfate.

TABLE 2
U.S. PRODUCERS OF NATURAL AND SYNTHETIC SODIUM SULFATE IN 1994

Product and company	Plant nameplate capacity (Thousand metric tons)	Plant location	Source
Sodium sulfate, natural:			
North American Chemical Co., Westend plant	218	Trona, CA	Dry lake brine.
Ozark-Mahoning Co. 1/	141	Seagraves, TX	Do.
Total	359		
Sodium sulfate, synthetic:			
Courtaulds North American Inc.	45	La Moyne, AL	Rayon manufacture.
Flour Corp., Doe Run Co.	9	Boss, MO	Battery recycling.
4M Paper Corp.	6	Ft. Madison, IA	Pulping process.
FMC Corp.	41	Bessemer City, NC	Lithium carbonate.
W. R. Grace & Co. Organic Chemicals Div.	8	Nashua, NH	Chelating agents.
Hoffman- La Roche Inc.	14	Belvidere, NJ	Ascorbic acid.
J. M. Huber	32	Etowah, TN	Silica pigment.
Do.	14	Havre de Grace, MD	Do.
Indspec Chemical Corp.	35	Petrolia, PA	Resorcinol manufacture.
Lenzing A.G.	34	Lowland, TN	Rayon manufacture.
North American Rayon Corp.	14	Elizabethton, TN	Do.
Occidental Chemical Corp.	109	Castle Hayne, NC	Sodium dichromate manufacture.
Pineville Kraft	3	Deer Park, TX	Pulping process.
Public Service of New Mexico	6	Waterflow, NM	Fluegas desulfurization.
Star Enterprise 2/	3	Delaware City, DE	Do.
Teepak, Inc.	6	Danville, IL	Cellulose manufacture.
Total	169		
Grand total	528		

1/ Ozark's Brownfield plant, owned by Atochem North America (formerly Pennwalt), was placed on standby in Sept. 1987; 64,000 tons of capacity is not included in total industry capacity.

2/ Owned by Saudi Refining Inc. (50%) and Texaco Inc. (50%).

TABLE 3
SODIUM SULFATE YEAREND PRICES

		1993		1994	
Sodium sulfate (100% Na_2SO_4):					
East, bulk, carlot, works, freight equalized	per ton	$113.00 -	$114.00	$113.00 -	$114.00
Gulf, bulk, carlot, same basis	do.		110.00		110.00
West, bulk, carlot, same basis	do.		127.00		127.00
Salt cake (100% Na_2SO_4):					
East, bulk, f.o.b. works	do.		72.00		72.00

Sources: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 245, No. 1, Jan. 3,1994,p. 31, and V. 247, No. 1, Dec. 30, 1994, p. 32.

TABLE 4
U.S. EXPORTS OF SODIUM SULFATE, BY COUNTRY 1/

Country	Disodium sulfate, salt cake		Disodium sulfate, other		Total	
	Quantity (Metric tons)	Value 2/	Quantity (Metric tons)	Value 2/	Quantity (Metric tons)	Value 2/
1993:						
Argentina	9,570	$957,000	1	$5,280	9,570	$962,000
Australia	17,900	1,790,000	2,550	564,000	20,500	2,350,000
Bermuda	--	--	16	5,430	16	5,430
Brazil	--	--	19	26,400	19	26,400
Canada	1,620	161,000	--	--	1,620	161,000
China	--	--	16	18,800	16	18,800
Colombia	22,900	1,120,000	445	155,000	23,400	1,270,000
El Salvador	--	--	968	115,000	968	115,000
Germany	--	--	18	50,400	18	50,400
Guatemala	--	--	4,000	460,000	4,000	460,000
Honduras	--	--	18	3,550	18	3,550
Hong Kong	--	--	1	3,900	1	3,900
Italy	798	86,900	--	--	798	86,900
Japan	--	--	172	83,200	172	83,200
Korea, Republic of	14,100	800,000	--	--	14,100	800,000
Mexico	472	57,600	2,650	802,000	3,120	859,000
Netherlands	--	--	1	3,800	1	3,800
New Zealand	6,660	618,000	--	--	6,660	618,000
Panama	--	--	44	180,000	44	180,000
Taiwan	--	--	115	53,800	115	53,800
Thailand	--	--	1	5,750	1	5,750
Venezuela	--	--	3,990	419,000	3,990	419,000
Total	74,000	5,590,000	15,000	2,950,000	89,000	8,540,000
1994:						
Australia	11,800	1,110,000	1	5,950	11,800	1,120,000
Belgium	4,610	410,000	--	--	4,610	410,000
Brazil	--	--	269	103,000	269	103,000
Canada	14,400	1,440,000	--	--	14,400	1,440,000
China	--	--	32	39,800	32	39,800
Colombia	7,510	300,000	--	--	7,510	300,000
Costa Rica	2,630	292,000	--	--	2,630	292,000
Dominican Republic	--	--	11	3,060	11	3,060
Ecuador	--	--	3	2,780	3	2,780
El Salvador	2,500	250,000	--	--	2,500	250,000
Guatemala	7,800	780,000	--	--	7,800	780,000
Honduras	--	--	20	5,100	20	5,100
Hong Kong	--	--	15	14,800	15	14,800
Japan	--	--	8	10,800	8	10,800
Korea, Republic of	7,030	415,000	(3/)	3,000	7,030	418,000
Mexico	750	85,200	5,190	1,700,000	5,940	1,780,000
Netherlands	--	--	3	12,700	3	12,700
Philippines	88	28,600	--	--	88	28,600
Spain	80	8,290	--	--	80	8,290
Total	59,200	5,120,000	5,550	1,900,000	64,800	7,020,000

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ F.a.s. value at U.S. ports.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 5
U.S. IMPORTS OF SODIUM SULFATE, BY COUNTRY 1/

Country	Disodium sulfate, salt cake 2/ 3/		Disodium sulfate, other		Total	
	Quantity (Metric tons)	Value 4/	Quantity (Metric tons)	Value 4/	Quantity (Metric tons)	Value 4/
1993:						
Canada	88,300	$8,480,000	73,000	$4,960,000	161,000	$13,400,000
Germany	33	71,500	6	3,080	39	74,600
Japan	1,150	52,500	--	--	1,150	52,500
Mexico	51	38,300	--	--	51	38,300
United Kingdom	41	31,200	--	--	41	31,200
Total	89,500	8,670,000	73,000	4,960,000	163,000	13,600,000
1994:						
Canada	107,000	10,100,000	68,700	5,270,000	176,000	15,400,000
Germany	252	28,500	51	69,500	303	98,000
India	--	--	21	23,000	21	23,000
Japan	795	156,000	--	--	795	156,000
Mexico	10	2,940	12,300	90,800	12,300	93,800
Total	108,000	10,300,000	81,100	5,460,000	190,000	15,700,000

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Salt cake is HTS No. 2833.11.1000.

3/ Includes Glauber's salt, HTS No. 2833.11.5050.

4/ C.i.f. value at U.S. ports.

Source: Bureau of the Census.

TABLE 6
SODIUM SULFATE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Natural:					
Argentina (mirabilite)	14,700 r/	16,100 r/	24,800 r/	6,550 r/	10,000
Canada 4/	345,000	332,000	282,000	320,000 r/	312,000 5/
Chile e/ 6/	13,500 5/	13,000	13,200	13,200	13,200
China e/ 7/	27,000	28,000	28,000	29,000	29,000
Egypt	41,400	41,100	41,000 e/	25,600 r/	25,000
Iran	177,000	144,000	237,000	280,000 r/	280,000
Mexico 8/ (bloedite)	545,000	518,000	534,000	500,000 e/	500,000
Netherlands e/	22,000	22,000	22,000	20,000	20,000
South Africa, Republic of	20 e/	--	37,200	36,400 r/	44,500 5/
Spain e/ 9/	716,000 5/	700,000	675,000	650,000	600,000
Turkey (concentrates)	110,000	115,000 e/	75,100	76,500 r/	80,000
Turkmenistan	XX	XX	100,000 e/	67,500 r/	50,000
U.S.S.R. e/ 10/	340,000	320,000	XX r/	XX r/	XX
United States	349,000	354,000	337,000	327,000	298,000 5/
Total	2,700,000	2,600,000	2,410,000 r/	2,350,000 r/	2,260,000
Synthetic:					
Austria e/	120,000	120,000	120,000	120,000	120,000
Belgium e/	250,000	260,000	250,000	250,000	250,000
Bosnia and Herzegovina e/	XX	XX	5,000	1,000	500
Brazil e/	9,000	9,000	9,000	9,000	9,000
Chile 11/	39,400 r/	33,800 r/	46,400 r/	45,000 r/ e/	46,000
Finland e/	33,000	33,000	30,000	30,000	30,000
France	120,000 e/	93,000	77,000	62,000 r/ e/	65,000
Germany:					
Eastern states	170,000 e/	XX	XX	XX	XX
Western states	167,000	XX	XX	XX	XX
Total	337,000 e/	146,000	114,000	107,000 r/	110,000
Greece e/	6,000	6,000	6,000	6,000	6,000
Hungary e/	8,000	6,000	6,000	6,000	6,000
Italy e/	125,000	125,000	125,000	125,000	125,000
Japan	253,000	250,000	243,000	229,000 r/	220,000
Macedonia e/	XX	XX	3,000	1,000	1,000
Netherlands e/	15,000	15,000	15,000	15,000	15,000
Pakistan e/	1,000	1,000	1,000	1,000	1,000
Portugal e/	50,000	50,000	50,000	50,000	50,000
Serbia and Montenegro	XX	XX	10,900 r/	10,000 r/ e/	8,000
Spain e/	150,000	150,000	150,000	150,000	150,000
Sweden e/	100,000	100,000	100,000	100,000	100,000
Turkey e/	27,000	30,000	30,000	30,000	30,000
U.S.S.R. e/ 10/	250,000	220,000	XX r/	XX r/	XX
United Kingdom e/	90,000	90,000	90,000	90,000	90,000
United States 12/	316,000	343,000	216,000 r/	210,000 r/	165,000 5/
Yugoslavia 13/	38,000	35,000 e/	XX	XX	XX
Total	2,340,000 r/	2,120,000 r/	1,700,000 r/	1,650,000 r/	1,600,000
Grand total	5,040,000 r/	4,720,000 r/	4,100,000 r/	4,000,000 r/	3,860,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data have been rounded by the U.S. Bureau of Mines to three significant digits; data may not add to totals shown.

2/ Table includes data available through May 19, 1995.

3/ In addition to the countries listed, Norway, Poland, Romania, and Switzerland are known or are assumed to have produced synthetic sodium sulfate, and other unlisted countries may have produced this commodity, but production figures are not reported, and general information is inadequate for the formulation of reliable estimates of output levels.

4/ Excludes byproduct production from chemical plants.

5/ Reported figure.

6/ Natural mine output, excluding byproduct output from the nitrate industry, which is reported separately under "Synthetic" in this table.

7/ Byproduct sodium sulfate is known to be recovered but reliable data are not available; not included under "Synthetic."

8/ Series reflects output reported by Industrias Penoles plus an additional 22,000 tons estimated production by Sulfato de Viesca.

9/ Na2SO4 content of glauberite and thenardite.

10/ Dissolved in Dec. 1991. Information is inadequate to formulate reliable estimates for individual countries other than Turkmenistan.

11/ Byproduct of nitrate industry.

12/ Derived approximate figures; data presented are the difference between reported total sodium sulfate production (natural and synthetic not differentiated) and reported natural sodium sulfate sold by producers (reported under "Natural" in this table).

13/ Dissolved in Apr. 1992.

CRUSHED STONE

By Valentin V. Tepordei

Crushed stone is one of the most accessible natural resources and a major basic raw material used by a wide range of industries from construction to agriculture, chemicals, and industrial processes. Despite the relative lowvalue of its basic products, the crushed stone industry is a major contributor to and an indicator of the economic well-being of the Nation.

A total of 1.23 billion metric tons of crushed stone was produced for consumption in the United States in 1994, a 9.8% increase compared with the total production of 1993. This tonnage represents the highest production level ever recorded in the United States, indicating a continued increase in the demand for construction aggregates in 1994. *(See table 1.)*

About three-quarters of the crushed stone production continued to be limestone and dolomite, followed by granite, traprock, sandstone and quartzite, miscellaneous stone, calcareous marl, marble, volcanic cinder and scoria, slate, and shell, in order of volume. *(See table 2.)*

Foreign trade of crushed stone continued to remain relatively small in 1994. Exports increased 7.3% to 5.2 million tons, while value decreased 3% to $38.1 million compared with that of 1993. Imports of crushed stone, including calcium carbonate, increased 5.8% to 8.9 million tons, while the value increased 4.7% to $77.8 million. Domestic apparent consumption of crushed stone was 1.23 billion tons. *(See tables 1, 22 and 23.)*

Legislation and Government Programs

Department of Transportation and Related Agencies Appropriation Act of 1994, (Public Law 103-122), was signed by the President on October 27, 1994. The Act appropriates $20.6 billion for new highway spending, a $2 billion increase from the fiscal year 1993 total. The Act also includes a $2.2 billion appropriation in grants for airport construction, and provision for a one-year delay in the imposition of the "crumb rubber" use in highway construction as required by the ISTEA Act of 1991.

Production

Domestic production data for crushed stone are developed by the U.S. Bureau of Mines (USBM) from voluntary surveys of U.S. producers. In response to the customers' requests to provide better statistical information on construction aggregates, the USBM reintroduced the annual surveys on crushed stone beginning with 1994 calendar year, in addition to the quarterly survey of crushed stone and sand and gravel.

Of the 5,127 crushed stone operations surveyed in 1994, 3,238 operations with 3,897 quarries were active. Of these, 2,523 operations with 3,118 quarries representing 77.9% of the total number of operations reported to the USBM survey and their total production, represented 89.2% of the total U.S. crushed stone output. The nonrespondent's production was estimated using employment data and/or adjusted prior years' production reports. Of the 2,523 reporting operations, 510 operations with 803 quarries did not report a breakdown by end use. Their production represented 21.4% of the U.S. total and is included in table 13 under "Unspecified uses, actual." The estimated production of 715 nonresponding operations represented 10.8% of the U.S. total and is included in table 13 under "Unspecified uses, estimated." A total of 751 quarries were either idle or presumed to have been idle in 1994 because no information was available to estimate their production. A total of 943 operations were closed down since 1993, the last year when a full survey of crushed stone producers was conducted. Most of the idle or closed operations were small temporary quarries operated by the State or local governments.

A total of 1.23 billion tons of crushed stone was produced for consumption in the United States in 1994, a 9.8% increase compared with that of 1993. This tonnage represents the highest production level ever recorded in the United States. *(See table 1.)* Of this total, 881 million tons or 71.7% was limestone and dolomite, 178 million tons or 14.5% was granite, and 91 million tons or 7.4% was traprock. The remaining 6.4% was shared, in descending order of quantity, by sandstone and quartzite, miscellaneous stone, calcareous marl, marble, slate, volcanic cinder and scoria, and shell. *(See table 2.)*

A comparison of the four major geographic regions indicates that in 1994 the South continued to lead the Nation in the production of crushed stone with 562.8 million tons or 45.8% of the total, followed by the Midwest with 380.1 million tons or 30.9%, and the Northeast with 162.0 million tons or 13.2%. Approximately 77% of the total U.S. crushed stone output was produced in two major geographic regions, the South and the Midwest. *(See table 3.)*

Of the nine geographic regions, the South Atlantic led the Nation in the production of crushed stone with 292.7 millions tons or 23.8% of the U.S. total. Next was the East North Central region with 228.7 or 18.7% of the total, followed by the West North Central with 150.4 million tons or 12.2%.

A comparison between the 1993 and 1994 production data by regions indicates that the output of crushed stone increased in all regions except the Mountain. The largest increases were recorded in the West North Central region, +20.9%; the New England, +19.7%; and the East South Central, +13.1%.

Crushed stone was produced in every State except Delaware and North Dakota. The 10 leading States in the production of crushed stone, in order of volume, were Pennsylvania, Texas, Missouri, Florida, Illinois, Virginia, Ohio, Kentucky, Georgia, and North Carolina. Their combined production represented 51.2% of the national total. Crushed stone was produced by 1,584 companies at 3,238 operations with 3,897 quarries. Leading U.S. producers in order of volume were, Vulcan Materials Co., Cornerstone Construction & Materials, Inc./Hanson Industries, Martin-Marietta Aggregates, CSR America Inc., and Rogers

Group, Inc.

Effective June 1, 1994, English China Clay's Construction Materials Division of Cheltenham, Gloucestershire, England, was "demerged" from the English China Clay PLC Group and a new company, CAMAS PLC, was created. These changes affected its U.S. subsidiary, the ECC Construction Materials America, Inc. of Lakewood, CO, that became CAMAS America, Inc.

In July, Tarmac America, Inc. of Herndon, VA, announced the reorganization of its operations into three product line groups: aggregates and cement, ready-mixed concrete, and concrete products. The company headquarters also were moved to Norfolk, VA.

In the second half of the year, Martin Marietta Aggregates of Raleigh, NC, purchased Dravo Corp.'s construction aggregates business. Included in the acquisition were 22 production facilities located in nine States and the Bahamas that became the Martin Marietta Central Region Division.

Limestone.—The 1994 output of crushed limestone, including some dolomite, increased 10.8% to 788 million tons valued at $3.9 billion, compared with the 1993 totals. *(See table 2.)* In addition to the quarries reporting only limestone, 64 operations with 76 quarries reported producing both limestone and dolomite, without making a distinction between the two kinds of stone. Their production, 25.7 million tons, was included with the limestone, and therefore, the limestone totals shown in this chapter include an undetermined amount of dolomite, in addition to the dolomite reported separately.

Limestone was produced by 917 companies at 1,896 operations with 1,996 quarries in 47 States. In addition, 46 companies with 64 operations and 67 quarries reported producing limestone and dolomite from the same quarries. Leading States, in order of tonnage, were Texas, Florida, Missouri, Kentucky, and Pennsylvania; these five States accounted for 37% of the total U.S. output. *(See table 8.)*

Leading U.S. producers were, in order of volume, Vulcan Materials Co., Cornerstone Construction & Materials, Inc./Hanson Industries, CSR America, Inc., Martin Marietta Aggregates, and Rogers Group, Inc.

Dolomite.—Production of dolomite increased 14.0% to 92.7 million tons valued at $479 million, compared with that of 1993. *(See table 2.)* Crushed dolomite was reportedly produced by 93 companies at 164 operations with 174 quarries in 26 States. An additional undetermined amount of dolomite is included in the total crushed limestone. Leading States in the production of dolomite, in order of tonnage, were Pennsylvania, Ohio, New York, Michigan, and Indiana; these five States accounted for 37.0% of the total U.S. output. *(See table 8.)*

Leading U.S. producers were Vulcan Materials Co.; Cornerstone Construction & Materials, Inc./Hanson Industries; Glasgow, Inc.; S. E. Johnson Companies/Stoneco, Inc.; and Asarco-American Limestone Co.

Marble.—Production of crushed marble increased 74.5% to 6.1 million tons valued at $65 million. *(See table 2.)* Crushed marble was produced by 13 companies with 26 operations and 45 quarries in 10 States.

Leading producers of crushed marble, in order of tonnage, were Georgia Marble Co., Columbia River Carbonates, and CAMAS America, Inc.

Calcareous Marl.—Output of marl increased 17.2% to 6.2 million tons valued at 32.2 million. *(See table 2.)* Marl was produced by 14 companies with 14 operations at 16 quarries in 8 States. South Carolina accounted for 52% of total U.S. output. *(See table 9.)*

Leading producers, in order of tonnage, were Holderbank Holnam Inc., Capitol Aggregates Inc., and Medusa Corp./Medusa Cement Co.

Shell.—Shell is mainly derived from fossil reefs or oyster shell. The output of crushed shell decreased 10.1% to 1.8 million tons valued at $10.3 million. *(See table 2.)* The decrease was mostly owing to the restrictions imposed on the industry in Louisiana as a result of concerns that shell dredging produces irreversible damage to the environment. Crushed shell was produced by 11 companies from 11 operations in 5 States. Leading producers, in order of tonnage, were Dravo Basic Materials Co., Quality Aggregates, Inc., and Leisey Shell Corp.

Granite.—The 1994 output of crushed granite increased 6.0% to 178 million tons valued at $1.1 billion. *(See table 2.)* Crushed granite was produced by 153 companies at 324 operations with 397 quarries in 33 States. Leading States, in order of tonnage, were Georgia, North Carolina, Virginia, South Carolina, and New Jersey; these five States accounted for 74.8% of the U.S. output. *(See table 10.)*

Leading U.S. producers, in order of tonnage, were Vulcan Materials Co., Martin Marietta Aggregates, Cornerstone Construction & Materials, Inc./Hanson Industries, Florida Rock Industries Inc., and Blue Circle America, Inc./Blue Circle Aggregates.

Traprock.—Production of crushed traprock increased 3.9% to 91.0 million tons valued at $576 million. *(See table 2.)* Traprock was produced by 265 companies at 379 operations with 591 quarries in 27 States. Leading States, in order of tonnage, were Oregon, Virginia, Washington, New Jersey, and Hawaii; these five States accounted for 60.9% of U.S. output. *(See table 10.)*

Leading U.S. producers, in order of tonnage, were Vulcan Materials Co., Luck Stone Corp., Stavola, Inc./Traprock Industries, Meridian Aggregates Co., and Cornerstone Construction & Materials, Inc./Hanson Industries.

Sandstone and Quartzite.—The combined output of crushed sandstone and quartzite increased 5.5% to 34.3 million tons valued at $212 million. *(See table 2.)* Crushed sandstone was produced by 110 companies at 138 operations with 193 quarries in 27 States, while crushed quartzite was produced by 33 companies at 34 operations with 37 quarries in 17 States. Leading States in the production of sandstone and quartzite in order of tonnage were Pennsylvania, Arkansas, and South Dakota; their combined production represented 43.6% of the U.S. output. *(See table 10.)*

Leading producers of sandstone and quartzite, in order of tonnage, were Ashland Oil, Inc.; APAC, Inc./Arkola Sand and Gravel Co., Western Mobile, Inc., and Oldcastle Inc./Callanan Industries, Inc.

Slate.—The 1994 output of crushed slate increased 30.6% to 2.7 million tons valued at $18.9 million. *(See table 2.)* Crushed slate was produced by 13 companies at 15 quarries in 6 States. Most of the crushed slate was produced in North Carolina.

Leading producers, in order of tonnage, were Martin Marietta Aggregates, Carolina Stalite Co., and Mariposa Aggregates Co.

Volcanic Cinder and Scoria.—Production of volcanic cinder and scoria decreased in 1994 13.5% to 2 million tons valued at $12.6 million. *(See table 2.)* Volcanic cinder and scoria were produced by 27 companies from 45 operations with 133 quarries in 14 States. Leading States, in order of volume were, California, New Mexico, and Hawaii; their combined production accounted for 44.5% of the total U.S. output. *(See table 11.)*

Leading producers, in order of tonnage, were Martin Marietta Aggregates, Stoney Point Rock Quarry Inc., and Byley H. G. & Sons Construction Co., Inc.

Miscellaneous Stone.—Output of other kinds of crushed stone increased 11.8% to 25.6 million tons valued at $150 million. *(See table 2.)* Miscellaneous stone was produced by 105 companies from 129 operations with 223 quarries in 28 States. Leading States, in order of volume, were Pennsylvania, California, and North Carolina; their combined production accounted for 38.2% of the total U.S. output. *(See table 11.)*

Consumption

Crushed stone production reported to the USBM is actually material that was either sold or used by producers. Stockpiled production is not included in the reported quantities. Therefore, the "sold or used" tonnage represents the amount of production released for domestic consumption or export in a given year. Because some of the crushed stone producers did not report a breakdown by end use, their total production is included in "Other unspecified uses, actual." The estimated production of nonrespondents is included in "Other unspecified uses, estimated."

In 1994, U.S. consumption of crushed stone was 1.2 billion tons valued at $6.6 billion, a 9.8% increase compared with that of 1993. Of the 1.2 billion tons of crushed stone consumed in 1994, 396 million tons or 32.2% of the total was unspecified uses - actual and estimated. Of the remaining 832 million tons, about 83.2% was used as construction aggregates, mostly for highway and road construction and maintenance; 13.6% for chemical and metallurgical uses, including cement and lime manufacture; 2% for agricultural purposes; and 1% for special uses and products. *(See table 13.)* To provide a more accurate estimation of the consumption patterns for crushed stone, the "Unspecified uses" are not included in the above percentages. It is recommended that in any use pattern or marketing analysis the quantities included in "Unspecified uses" be distributed among the reported uses by applying the above percentages to the "Unspecified uses total."

Limestone.—Of the 788 million tons of crushed limestone consumed, 245 million tons or 31.1% was "Unspecified uses - actual and estimated." Of the remaining 543 million tons of crushed limestone reported by uses by the producers, 77.1% was used as construction aggregates, 19% for chemical and metallurgical uses including cement and lime manufacturing, 2.6% for agricultural purposes, and 1.1% for special uses and products. *(See table 14.)*

Dolomite.—Of the 93 million tons of crushed dolomite consumed, 6 million tons or 6.4% was "Unspecified uses - actual and estimated." Of the remaining 87 million tons of crushed dolomite reported by uses by the producers, 90.1% was used as construction aggregates, 5.6% for chemical and metallurgical uses, and 2.6% for agricultural purposes. An additional undefined amount of dolomite consumed in a variety of uses, mostly construction aggregates, is reported with the limestone. *(See table 14.)*

Marble.—Of the 6.1 million tons of crushed marble consumed, 3.3 million tons or 54.9% was reported as "Other unspecified uses." Of the remaining 2.8 million tons of crushed marble reported by uses by the producers, 1.6 million tons or 56.5% was used as miscellaneous uses, including fillers and extenders, and 1.1 million tons or 41.8% as construction aggregates. *(See table 16.)*

Calcareous Marl.—Of the 6.2 million tons of crushed calcareous marl consumed, 2.6 million tons or 42% was reported as "Other unspecified uses." Of the remaining 3.6 million tons of crushed marl reported by uses by the producers, 79.2% was used for cement manufacturing, and the remaining 20.8% as construction aggregates and for agricultural purposes.

Shell.—Of the 1.8 million tons of crushed shell consumed, 115,000 tons or 6.4% was reported as "Other unspecified uses." Of the remaining 1.7 million tons of crushed shell reported by uses by the producers, 98.8% was used as construction aggregates.

Granite.—Of the 178 million tons of crushed granite consumed, 71 million tons or 39.9% was reported as "Other unspecified uses." Most of the remaining 107 million tons of crushed granite reported by uses by the producers was used as construction aggregates. *(See table 17.)*

Traprock.—Of the 91 million tons of crushed traprock consumed, 33 million tons or 36.4% was reported as "Other unspecified uses." Most of the remaining 58 million tons of crushed traprock reported by uses by the producers was used as construction aggregates. *(See table 17.)*

Sandstone and Quartzite.—Of the 27.4 million tons of crushed sandstone consumed, 13.3 million tons or 48.4% was reported as "Other unspecified uses." Most of the remaining 14.2 million tons of crushed sandstone reported by uses by the producers, was used as construction aggregates. *(See table 18.)*

Of the 6.8 million tons of crushed quartzite consumed, 3.1 million tons or 45.6% was reported as "Other unspecified uses." Most of the remaining 3.7 million tons of crushed quartzite reported by uses by the producers was used as construction aggregates. *(See table 18.)*

Volcanic Cinder and Scoria.—Of the 2.1 million tons of volcanic cinder and scoria consumed, 794,000 tons or 38.6% was reported as "Other unspecified uses." Most of the remaining 1.3 million tons of crushed volcanic cinder and scoria reported by uses by the producers was used as construction aggregates. *(See table 19.)*

Miscellaneous Stone.—Of the 36.3 million tons of miscellaneous crushed stone consumed, 20.7 million tons or 56.9% was reported as "Other unspecified uses." Of the remaining 15.6 million tons reported by uses by the producers, 81.8% was used as construction aggregates and 18.2% was used for cement manufacturing. *(See table 19.)*

Prices

Prices in this chapter are f.o.b. plant, usually at the first point of sale or captive use. This value does not include transportation from the plant or yard to the consumer. It does, however, include all costs of mining, processing, in-plant transportation, overhead costs and profit.

The 1994 average unit price per ton of crushed stone increased 1.6% to $5.38, compared with that of 1993. By kind of stone, the average unit prices showed modest increases of 4.3% for calcareous marl and miscellaneous stone, 4.2% for granite, 3.7% for sandstone and quartzite, 3.6% for traprock, 3.1% for slate, 2% for limestone, and 0.5% for volcanic cinder and scoria. At the same time, the average unit prices decreased for marble 49.6%, for shell 8.2%, and for dolomite 4%. *(See table 2.)*

Transportation

No means of transportation was reported by the producers for 424 million tons or 34.5% of the total 1.23 billion tons of crushed stone produced for consumption in 1994. Of the remaining 806 million tons of crushed stone, 582 million tons or 72.2% was reported as transported by truck from the processing plant or quarry to the first point of sale or use, 6.8% was transported by rail, and 7.1% by waterway. About 11.3% of the total production was reported as not transported and therefore used on-site. Information regarding means of transportation used by the producers to ship crushed stone in each geographic regions is also provided. *(See table 20.)*

Foreign Trade

The widespread distribution of domestic crushed stone deposits and the high cost of transportation limits foreign trade mostly to local transactions across international boundaries. U.S. imports and exports are small, representing less than 0.5% of the domestic consumption. However, shipments of crushed stone by water from Canada and especially Mexico are increasing.

Exports.—Exports of crushed stone increased 7.3% to 5.2 million tons compared with that of 1993, while value decreased 3% to $38.1 million. About 96.3% of the exported crushed stone was limestone, Canada being the major destination with 87.8% of the total crushed stone exported. *(See table 22.)*

Imports.—Imports of crushed stone increased 5.8% to 8.9 million tons compared with that of 1993, while the value increased 4.7% to $77.8 million. About 93.5% of the imported crushed stone was limestone.

Imports of natural calcium carbonate fines decreased significantly from 44,000 tons to 5,000 tons. *(See table 23.)*

Shipments of crushed stone from the Bahamas, Canada, and Mexico into the United States continued in 1993. The imported crushed stone was used mostly as construction aggregates or for cement manufacturing. This trend is expected to continue, and the volume of imports, especially from Mexico, to increase.

Outlook

The demand for crushed stone in 1995 is expected to be about 1.3 billion tons, a 5% increase compared with that of 1994. Gradual increases in demand for construction aggregates are anticipated after 1995 as well, based on the volume of work on the infrastructure that is being financed by the Intermodal Surface Transportation Efficiency Act of 1991 and the U.S. economy in general. The projected increases will be influenced by construction activity primarily in the public as well as the private construction sector.

Crushed stone f.o.b. prices are not expected to increase significantly. However, the delivered prices of crushed stone are expected to increase, especially in and near metropolitan areas, mainly because more aggregates are transported from distant sources.

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TABLE 1
SALIENT U.S. CRUSHED STONE STATISTICS 1/

		1990	1991	1992	1993	1994
Sold or used by producers:						
Quantity 2/	thousand metric tons	1,110,000	997,000	1,050,000	1,120,000	1,230,000
Value 2/	thousands	$5,590,000 e/	$5,140,000	$5,590,000 e/	$5,930,000 r/	$6,620,000
Exports	value, thousands	$41,400	$33,000	$43,400	$39,300	$38,100
Imports3/	do.	$35,300	$38,600	$60,700	$74,300	$77,800

e/Estimated. r/Revised.

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/Does not include American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands.

3/Excludes precipitated calcium carbonate.

TABLE 2
CRUSHED STONE SOLD OR USED IN THE UNITED STATES, BY KIND 1/

Kind	1993 r/				1994			
	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand metric tons)	Value (thousands)	Unit value
Limestone 2/	2,090	711,000	$3,480,000	$4.90	2,070	788,000	$3,940,000	$5.00
Dolomite	160	81,300	438,000	5.38	174	92,700	479,000	5.17
Marble	36	3,490	73,900	21.17	45	6,090	65,100	10.68
Calcareous marl	13	5,280	26,400	4.99	16	6,190	32,200	5.20
Shell	15	1,990	12,500	6.27	11	1,790	10,300	5.75
Granite	469	168,000	1,010,000	6.04	398	178,000	1,120,000	6.29
Traprock	600	87,600	535,000	6.11	591	91,000	576,000	6.33
Sandstone and quartzite	230	32,500	194,000	5.96	230	34,300	212,000	6.18
Slate	13	2,090	14,100	6.73	15	2,730	18,900	6.94
Volcanic cinder and scoria	126	2,380	14,500	6.10	133	2,060	12,600	6.13
Miscellaneous stone	165	22,900	129,000	5.61	224	25,600	150,000	5.85
Total	XX	1,120,000	5,930,000	5.30	XX	1,230,000	6,620,000	5.39

r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices; may not add to totals shown.

2/ Includes "Limestone-dolomite," reported with no distinction between the two.

TABLE 3
CRUSHED STONE 1/ SOLD OR USED IN THE UNITED STATES, BY REGION 2/

(Thousand metric tons and thousand dollars)

Region	1993		1994	
	Quantity	Value	Quantity	Value
Northeast:				
New England	21,800	169,000	26,100	207,000
Middle Atlantic	126,000	788,000	136,000	854,000
Midwest:				
East North Central	208,000	923,000	230,000	1,040,000
West North Central	124,000	602,000	150,000	758,000
South:				
South Atlantic	270,000 r/	1,560,000 r/	293,000	1,750,000
East South Central	124,000	637,000	140,000	697,000
West South Central	123,000 r/	526,000 r/	130,000	572,000
West:				
Mountain	37,200 r/	209,000 r/	35,800	199,000
Pacific	83,300 r/	516,000 r/	87,600	541,000
Total	1,120,000	5,930,000 r/	1,230,000	6,620,000

r/ Revised.

1/ Includes volcanic cinder and scoria.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 4
CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY QUARTER AND REGION 1/

(Thousand metric tons and thousand dollars)

Region	Quantity 1st quarter	Percent change 2/	Quantity 2nd quarter	Percent change 2/	Quantity 3rd quarter	Percent change 2/	Quantity 4th quarter	Percent change 2/	Total 3/	Value total 3/
Northeast:										
New England	900	-10.5	6,300	2.2	7,900	5.3	7,100	10.6	22,200	176,700
Middle Atlantic	11,700	-11.9	38,100	4.5	45,700	7.4	38,100	18.2	133,600	858,200
Midwest:										
East North Central	25,000	5.7	64,800	13.8	71,700	5.2	64,500	9.2	226,000	1,032,200
West North Central	22,100	20.4	36,500	11.8	42,500	10.9	33,900	0.1	134,900	673,000
South:										
South Atlantic	54,900	10.6	82,000	11.2	85,000	13.3	78,700	16.1	300,600	1,788,200
East South Central	23,800	10.7	37,700	13.7	41,400	13.1	37,300	15.7	140,300	744,800
West South Central	30,000	17.7	33,700	7.8	37,300	9.4	31,400	9.4	132,400	582,400
West:										
Mountain	6,700	-1.4	9,900	-2.8	11,300	-7.4	9,000	9.6	36,800	213,600
Pacific 4/	15,600	23.0	18,700	11.5	20,600	0.2	19,700	-2.6	74,600	471,200
Total 3/	190,700	10.6	327,600	10.2	363,500	8.5	319,700	10.7	1,224,600 5/	6,724,600 5/

1/ As published in the "Crushed Stone and Sand and Gravel in the Fourth Quarter of 1994" Mineral Industry Survey.

2/ All percentage changes are calculated using unrounded totals.

3/ Data may not add to totals shown because of independent rounding, and differences between projected totals by States and by regions.

4/ Does not include Alaska and Hawaii.

5/ Includes Alaska, Hawaii, and "Other;" see table 6.

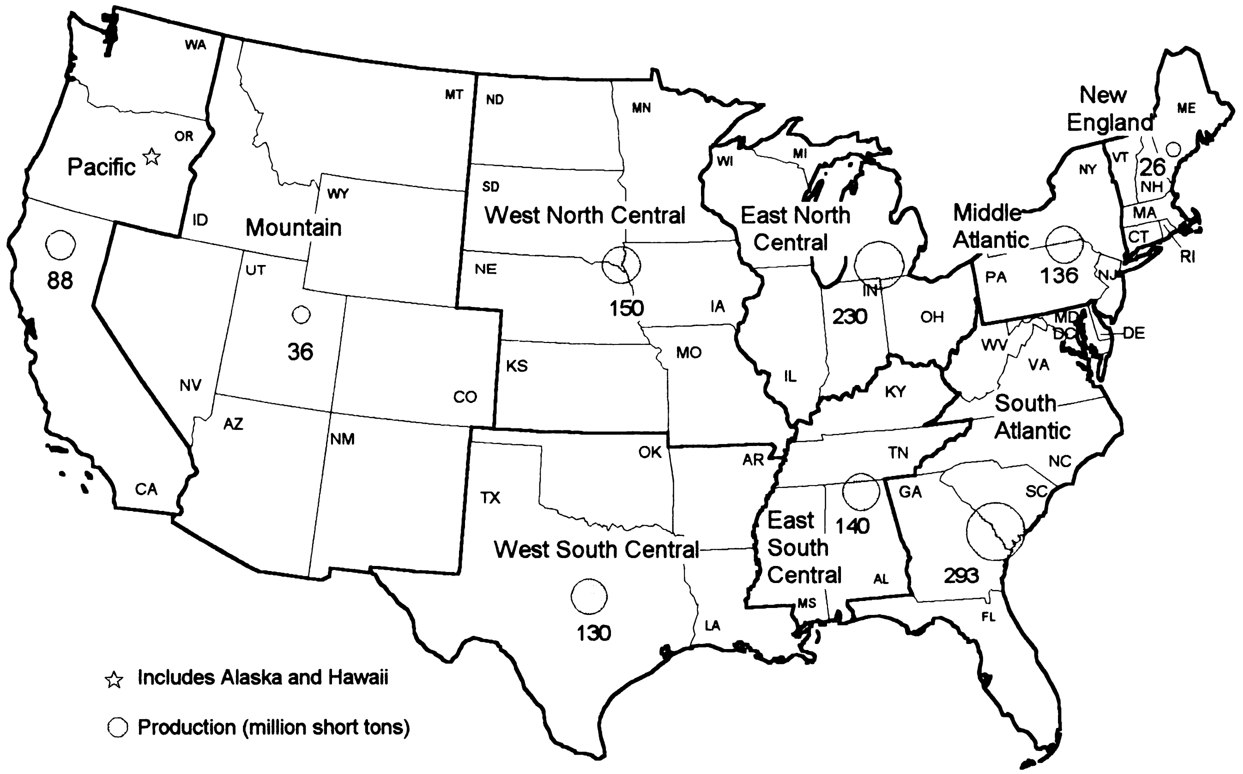

Figure 1 - Production of crushed stone in the United States in 1994, by geographic region

TABLE 5
CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/ 2/

State	1993			1994		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	28,900	$176,000	$6.08	32,500	$164,000	$5.07
Alaska 3/	3,530 r/ 4/	25,000 r/ 4/	7.07	3,870	24,100	6.24
Arizona	6,240 r/	35,600 r/	5.71	4,970	25,000	5.03
Arkansas	22,200 r/ 5/	108,000 5/ 6/	4.86	20,800 6/ 7/	122,000 6/ 7/	5.83
California	38,700 r/	252,000 r/	6.51	41,100	258,000	6.29
Colorado	10,300	62,000	5.96	8,600	53,600	6.23
Connecticut	4,600 4/ 8/	39,500 4/ 8/	8.59	5,710	51,000	8.93
Florida	64,900	313,000 9/	4.83	67,000	343,000	5.13
Georgia	49,400	292,000	5.92	54,600	331,000	6.07
Hawaii	8,460 8/	81,400 8/	9.63	8,170	82,300	10.08
Idaho	4,600	20,800	4.51	4,160	20,300	4.89
Illinois	61,500 4/	315,000 4/	5.13	62,600 8/	353,000 8/	5.64
Indiana	36,900	166,000	4.50	45,900	211,000	4.61
Iowa	30,500	169,000	5.53	36,600 8/	211,000 5/ 8/	5.75
Kansas	18,800 4/	90,700 4/	4.81	21,500	103,000	4.82
Kentucky	49,000 4/	226,000 4/	4.61	56,300	259,000	4.61
Louisiana	W	W 7/ 8/ 10/	10.91 r/	707 8/ 10/	7,710 8/ 10/	10.91
Maine	1,830	10,400	5.65	2,740	15,500	5.65
Maryland	21,000 r/	139,000 r/	6.60	24,100 8/	162,000 8/	6.73
Massachusetts	9,460 5/ 8/	76,300 5/ 8/	8.07	10,500	97,300	9.29
Michigan	31,000	112,000	3.60	35,000	113,000	3.23
Minnesota	9,420	37,700	4.00	10,900	47,100	4.33
Mississippi	2,100	8,120	3.86	1,900	7,500	3.95
Missouri	53,400	239,000	4.48	68,900	330,000	4.80
Montana	2,820	10,400	3.68	2,320	8,830	3.80
Nebraska	6,760	38,900	5.75	6,890	41,600	6.04
Nevada	1,610	12,500	7.80	2,310	20,600	8.93
New Hampshire	1,390	7,790	5.61	1,390 7/	7,470 7/	5.39
New Jersey	16,700 4/ 7/	138,000 4/ 7/	8.25	19,800	154,000	7.80
New Mexico	3,580 r/	19,000 r/	5.31	3,550 6/ 11/	20,000 6/ 11/	5.62
New York	38,400	223,000 6/	5.81	39,400	239,000	6.05
North Carolina	47,800 11/ 12/ 13	298,000 11/ 12/ 13	6.23	53,900	351,000	6.51
North Dakota	W 13/	W 13/	W 13/	--	--	
Ohio	51,800 r/	227,000 r/	4.37	56,400	251,000	4.45
Oklahoma	27,100	114,000	4.21	29,900	125,000	4.18
Oregon	18,900	84,700	4.48	18,900	90,100	4.76
Pennsylvania	70,100 r/	409,000 r/	5.83	76,700	462,000	6.02
Rhode Island	1,290	9,250	7.17	1,610	12,200	7.58
South Carolina	19,800	121,000	6.12	20,000 14/	128,000 14/	6.39
South Dakota	4,230 4/ 8/	18,700 4/ 8/	4.42	5,470 8/	24,500 8/	4.47
Tennessee	43,500	227,000	5.20	49,200	265,000	5.39
Texas	71,700 r/	281,000 r/	3.96	76,100	300,000	3.95
Utah	4,560	29,400	6.45	4,540	19,800	4.37
Vermont	2,520	12,900	5.12	4,170	23,700	5.68
Virginia	51,000	292,000	5.73	56,700	327,000	5.77
Washington	13,200	68,600	5.20	15,500	86,100	5.54
West Virginia	10,300 5/	79,700	7.72	12,300 5/	99,300	8.10
Wisconsin	26,200	98,000	3.73	28,500	114,000 11/	4.01
Wyoming	3,460	19,800	5.74	5,080	30,000	5.91
Other	12,400 r/	98,000 r/	7.92	8,800	24,700	2.81
Total	1,120,000	5,930,000 r/	5.29	1,230,000	6,620,000	5.39

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices; may not add to totals shown.

2/ To avoid disclosing company proprietary data, certain State totals do not include all kinds of stone produced within the State; the portion not shown has been included with "Other."

3/ Data derived in part from the Alaska Geological Survey.

4/ Excludes sandstone.

5/ Excludes dolomite.

6/ Excludes traprock.

7/ Excludes limestone.

8/ Excludes other.

9/ Excludes limestone-dolomite.

10/ Excludes shell.

11/ Excludes quartzite.

12/ Excludes slate.

13/ Excludes volcanic cinder.

14/ Excludes marble.

TABLE 6
CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY QUARTER AND STATE 1/

(Thousand metric tons and thousand dollars)

State	Quantity 1st quarter	Percent change 2/	Quantity 2nd quarter	Percent change 2/	Quantity 3rd quarter	Percent change 2/	Quantity 4th quarter	Percent change 2/	Total	Value total
Alabama	6,600	14.3	8,200	4.4	8,600	5.6	8,200	15.4	31,600	193,700
Alaska 4/	--	--	--	--	--	--	--	--	2,500	11,900
Arizona	1,500	3.1	1,600	3.2	1,800	-2.0	1,700	8.7	6,600	38,300
Arkansas 5/	4,600	7.2	6,500	15.7	8,000	26.4	6,200	12.0	25,300	122,700
California	9,000	33.2	9,600	5.6	10,300	-5.7	10,500	-7.1	39,400	262,000
Colorado	1,500	-14.0	2,500	-12.3	2,800	-21.2	2,100	-7.9	8,900	54,300
Connecticut 5/	200	42.8	1,300	1.3	2,100	27.0	1,800	15.9	5,400	47,300
Delaware 4/	--	--	--	--	--	--	--	--	--	--
Florida	17,800	10.2	19,200	14.8	19,800	23.9	18,400	14.2	75,200	376,000
Georgia	10,900	14.8	14,500	6.3	15,200	7.4	14,400	18.9	55,000	330,000
Hawaii 4/ 5/	--	--	--	--	--	--	--	--	8,700	84,000
Idaho 6/	--	--	--	--	--	--	--	--	3,700	17,000
Illinois 5/	7,600	7	18,900	13.9	21,400	5.9	19,100	8.0	67,000	355,100
Indiana	6,300	22.7	12,600	30.3	12,600	6.5	12,200	19.3	43,700	205,400
Iowa	4,100	8.9	8,700	-3.8	9,300	-2.1	7,500	-8.5	29,600	165,800
Kansas 5/	3,900	11.2	5,300	6.6	6,400	19.5	4,300	-13.3	19,900	98,500
Kentucky 5/	8,600	-1.1	15,200	19.6	16,200	10.9	14,300	10.5	54,300	260,600
Louisiana 5/ 6/	--	--	--	--	--	--	--	--	--	--
Maine	200	-14.0	600	8.0	700	44.1	600	2.4	2,100	12,300
Maryland	3,200	10.9	7,000	7.2	7,600	9.8	7,500	12.2	25,300	172,000
Massachusetts 5/	200	-31.8	2,800	-1.8	2,800	-19.6	2,700	-5.0	8,500	68,900
Michigan	1,800	-7.1	8,900	-6.2	10,800	3.1	10,900	19.9	32,400	118,300
Minnesota	600	47.3	2,800	12.7	4,100	2.0	2,800	9.9	10,300	44,800
Mississippi 6/	--	--	--	--	--	--	--	--	1,800	7,000
Missouri	12,800	33.4	16,400	21.9	19,200	34.0	17,900	11.9	66,300	314,900
Montana	300	-19.3	700	11.3	600	-51.7	500	-7.7	2,100	8,000
Nebraska	1,300	22.5	2,000	30.4	2,200	-13.0	1,400	-10.8	6,900	40,700
Nevada	400	6.4	700	78.6	100	-61.1	500	7.1	1,700	13,400
New Hampshire	100	32.6	500	45.6	700	37.4	800	86.9	2,100	12,200
New Jersey 5/	1,400	-34.3	5,100	8.7	5,600	13.1	6,100	20.8	18,200	153,800
New Mexico 5/	600	3.4	900	14.1	1,100	2.2	700	-29.6	3,300	18,000
New York.	2,700	-17.2	11,300	-2.4	15,100	8.7	10,000	4.1	39,100	228,700
North Carolina 5/	9,400	10.8	14,600	7.3	15,200	9.8	13,700	15.5	52,900	343,900
North Dakota 5/ 6/	--	--	--	--	--	--	--	--	--	--
Ohio	6,700	-1.8	16,300	15.8	17,000	2.3	13,800	-5.1	53,900	250,600
Oklahoma	7,200	21.2	7,500	3.5	8,700	26.0	7,900	12.3	31,300	139,300
Oregon	3,700	7.2	4,700	5.2	5,900	9.7	5,400	-3.4	19,700	92,600
Pennsylvania 5/	7,700	-2.5	21,800	7.8	25,000	5.1	22,000	26.0	76,500	455,200
Rhode Island 6/	--	--	--	--	--	--	--	--	1,700	12,300
South Carolina	4,400	10.4	5,900	6.4	5,600	8.2	5,300	3.1	21,200	132,300
South Dakota 5/	500	-16.8	1,400	25.2	1,300	-8.7	1,100	4.0	4,300	19,600
Tennessee	7,900	23.5	14,100	17.4	16,400	22.6	14,400	21.9	52,800	287,800
Texas	18,000	18.5	19,800	7.9	20,800	-1.3	17,300	7.2	75,900	315,000
Utah	1,500	27.4	1,000	-13.7	1,800	56.7	1,300	22.8	5,600	37,500
Vermont 6/	--	--	--	--	--	--	--	--	2,600	13,900
Virginia	8,200	3.3	17,300	20.4	17,400	14.3	16,200	21.1	59,100	351,600
Washington	2,800	11.8	4,600	47.1	4,600	6.3	3,900	21.2	15,900	86,700
West Virginia 5/	1,800	16.4	4,000	37.9	5,000	52.3	3,600	43.3	14,400	114,500
Wisconsin	2,400	-15.9	7,900	15.1	10,100	11.8	7,900	5.6	28,300	114,600
Wyoming	400	2.9	1,200	-6.2	1,500	24.2	1,100	92.8	4,200	25,000
Other	--	--	--	--	--	--	--	--	12,000	96,600
Total 3/	XX	XX	XX	XX	XX	XX	XX	XX	1,224,600	6,724,600

XX Not applicable.

1/ As published in the "Crushed Stone and Sand and Gravel in the Fourth Quarter of 1994" Mineral Industry Survey.

2/ All percentage change are calculated using unrounded totals.

3/ Data may not add to totals shown because of independent rounding, and differences between projected totals by States and by regions.

4/ State not included in quarterly survey.

5/ To avoid disclosing company proprietary data, certain State totals do not include all kinds of stone produced within the State; the portion not shown has been included with "Other."

6/ Due to low number of companies, no production estimates by quarter were generated.

TABLE 7
CRUSHED STONE SOLD OR USED IN THE UNITED STATES IN 1994, BY REGION AND SIZE OF OPERATION 1/

Size range (Metric tons)	Northeast				Midwest				South			
	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total
Less than 25,000	54	12.0	390	--	226	19.0	2,060	--	69	7.0	736	--
25,000 to 49,999	14	3.0	466	--	127	10.0	4,200	1.0	44	4.0	1,490	--
50,000 to 99,999	40	9.0	2,760	1.0	155	13.0	10,500	2.0	78	8.0	5,310	--
100,000 to 199,999	67	15.0	9,220	5.0	184	15.0	24,300	6.0	116	12.0	15,700	2.0
200,000 to 299,999	52	12.0	11,900	7.0	120	10.0	26,800	7.0	90	9.0	20,200	3.0
300,000 to 399,999	43	10.0	13,300	8.0	77	6.0	24,400	6.0	65	6.0	20,800	3.0
400,000 to 499,999	34	8.0	14,000	8.0	67	5.0	27,400	7.0	67	7.0	27,300	4.0
500,000 to 599,999	21	4.0	10,500	6.0	28	2.0	13,900	3.0	68	7.0	33,900	6.0
600,000 to 699,999	15	3.0	8,780	5.0	24	2.0	14,100	3.0	54	5.0	32,000	5.0
700,000 to 799,999	15	3.0	10,300	6.0	27	2.0	18,300	4.0	45	4.0	30,500	5.0
800,000 to 899,999	18	4.0	13,800	8.0	26	2.0	20,100	5.0	35	3.0	27,300	4.0
900,000 to 999,999	11	2.0	9,460	5.0	23	1.0	19,900	5.0	30	3.0	26,000	4.0
1,000,000 to 1,499,999	29	6.0	30,500	18.0	52	4.0	57,300	15.0	107	11.0	119,000	21.0
1,500,000 to 1,999,999	5	1.0	7,710	4.0	21	1.0	32,600	8.0	42	4.0	67,400	12.0
2,000,000 to 2,499,999	--	--	--	--	10	--	20,500	5.0	12	1.0	24,500	4.0
2,500,000 to 4,999,999	7	1.0	18,800	11.0	11	--	34,100	9.0	22	2.0	65,600	11.0
5,000,000 and over	--	--	--	--	5	--	29,600	7.0	6	--	45,300	8.0
Total	425	100.0	162,000	100.0	1,180	100.0	380,000	100.0	950	100.0	563,000	100.0

Size range (Metric tons)	West				U.S. total			
	Number of operations	Percent of total	Quantity (thousand metric tons)	Percent of total	Number of operations	Percent of total	Quantity (thousand metric tions)	Percent of total
Less than 25,000	232	34.0	1,730	1.0	581	17.0	4,910	--
25,000 to 49,999	97	14.0	3,270	2.0	282	8.0	9,430	--
50,000 to 99,999	109	16.0	7,060	5.0	382	11.0	25,700	2.0
100,000 to 199,999	88	12.0	11,500	9.0	455	14.0	60,700	4.0
200,000 to 299,999	43	6.0	9,560	7.0	305	9.0	68,500	5.0
300,000 to 399,999	26	3.0	8,080	6.0	211	6.0	66,600	5.0
400,000 to 499,999	18	2.0	7,170	6.0	186	5.0	76,000	6.0
500,000 to 599,999	8	1.0	3,870	3.0	125	3.0	62,100	5.0
600,000 to 699,999	10	1.0	5,910	4.0	103	3.0	60,800	5.0
700,000 to 799,999	11	1.0	7,560	6.0	98	3.0	66,600	5.0
800,000 to 899,999	7	1.0	5,410	4.0	86	2.0	66,600	5.0
900,000 to 999,999	6	--	5,160	4.0	70	2.0	60,500	4.0
1,000,000 to 1,499,999	8	1.0	8,570	6.0	196	6.0	215,000	17.0
1,500,000 to 1,999,999	7	1.0	10,700	8.0	75	2.0	118,000	9.0
2,000,000 to 2,499,999	7	1.0	13,800	11.0	29	--	58,900	4.0
2,500,000 to 4,999,999	5	--	13,900	11.0	45	1.0	132,000	10.0
5,000,000 and over	--	--	--	--	11	--	74,900	6.0
Total	682	100.0	123,000	100.0	3,240	100.0	1,230,000	100.0

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 8
CRUSHED LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	Limestone		Dolomite	
	Quantity	Value	Quantity	Value
Alabama	28,300 2/	117,000 2/	W	W
Arizona	2,710	10,500	--	--
Arkansas	6,870	33,500	W	W
California	23,300	149,000	208	1,550
Colorado	2,550	13,900	--	--
Connecticut	W	W	408	W
Florida	64,200 2/	330,000 2/	W	W
Georgia	5,090 2/	31,000 2/	--	--
Hawaii	W	10,500	--	--
Idaho	W	1,400	--	--
Illinois	47,600 2/	276,000 2/	W	W
Indiana	40,000 2/	183,000 2/	5,840	28,000
Iowa	36,600 2/	211,000 2/	33	
Kansas	20,600 2/	98,500 2/	--	--
Kentucky	56,100 2/	257,000 2/	--	--
Maine	1,530	9,450	--	--
Maryland	16,900	114,000	--	--
Massachusetts	1,710 2/	19,000 2/	W	W
Michigan	27,900 2/	90,000 2/	6,810	22,200
Minnesota	7,670	32,700	W	W
Mississippi	W	W	--	--
Missouri	64400 2/	303000 2/	2960	13,600
Montana	1,410	6,010	--	--
Nebraska	6,890	41,600	--	--
Nevada	W	13,000	W	W
New Hampshire	W	W	--	--
New Jersey	W	W	--	--
New Mexico	1,880	8,660	--	--
New York	27,400 2/	142,000 2/	7,540	55,800
North Carolina	W	W	245	1,680
Ohio	41,700 2/	190,000	14,500	59,900
Oklahoma	22,600	91,200	1,820	7,550
Oregon	W	W	--	--
Pennsylvania	44,000 2/	256,000	14,700	90,000
Rhode Island	W	W	--	--
South Carolina	W	W	--	--
South Dakota	2,850	9,520	--	--
Tennessee	43,500 2/	237,000	W	W
Texas	72,000	285,000	W	W
Utah	1,980 2/	12,300	W	W
Vermont	1,800	11,200	234	1,220
Virginia	16,300	89,800	3,650	27,800
Washington	2,140 2/	23,600 2/	W	W
West Virginia	10,200	66,000	W	19,200
Wisconsin	21,900 2/	89,200 2/	W	W
Wyoming	1,520 2/	6,120 2/	--	--
Other	14,000 2/	73,300 2/	33,800	151,000
Total	788,000	3,940,000	92,700	479,000

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes "limestone/dolomite," reported with no distinction between the two.

TABLE 9
CRUSHED CALCAREOUS MARL AND MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY STATE 1/

(Thousand metric tons and thousand dollars)

	Calcareous Marl		Marble	
State	Quantity	Value	Quantity	Value
Alabama	--	--	W	W
Arizona	--	--	593	3,730
Florida	W	W	--	--
Georgia	W	W	W	W
Maine	W	W	--	--
Michigan	W	W	--	--
Mississippi	26	203	--	--
New York	--	--	87	1,610
North Carolina	111	738	--	--
Pennsylvania	--	--	476	3,210
South Carolina	3,220	21,500	W	W
Texas	W	W	W	W
Vermont	--	--	839	4,730
Washington	--	--	W	W
Wyoming	--	--	93	3,250
Other	2,840	9,750	4,010	48,600
Total	6,190	32,200	6,090	65,100

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 10
CRUSHED GRANITE, TRAPROCK, AND SANDSTONE AND QUARTZITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	Granite		Traprock		Sandstone and quartzite	
	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	--	--	--	--
Alaska 2/	W	W	1,280	5,520	W	W
Arizona	1,330	7,870	W	W	W	W
Arkansas	7,090	52,600	W	W	5,290	25,300
California	4,880	23,400	6,090	43,500	1,120	6,310
Colorado	3,180	16,500	--	--	W	W
Connecticut	119	1,350	3,750	30,100	--	--
Georgia	47,200	287,000	--	--	W	W
Hawaii	--	--	6,150	61,100	--	--
Idaho	281	1,110	2,230	9,440	556	4,800
Illinois	--	--	--	--	W	W
Kansas	--	--	--	--	W	W
Kentucky	--	--	--	--	W	W
Louisiana	--	--	--	--	707	7,710
Maine	W	W	W	W	--	--
Maryland	4,940	31,600	W	W	242	2,000
Massachusetts	2,850	W	5,860	48,700	--	--
Michigan	--	--	19	43	W	W
Minnesota	W	W	W	W	W	W
Missouri	W	W	--	--	W	W
Montana	W	W	W	W	W	W
Nevada	W	W	W	W	--	--
New Hampshire	1,060	5,070	W	W	--	--
New Jersey	7,460	58,200	10,600	78,600	W	W
New Mexico	1,250	8,620	W	W	W	W
New York	2,430	20,400	W	W	798	5,420
North Carolina	41,300	265,000	3,930	25,800	W	W
Ohio	--	--	--	--	232	832
Oklahoma	W	W	W	W	W	W
Oregon	54	235	15,200	71,500	W	W
Pennsylvania	2,570	15,800	2,650	21,700	7,030	45,500
Rhode Island	W	W	W	W	--	--
South Carolina	15,200	97,600	--	--	--	--
South Dakota	--	--	--	--	2,620	15,000
Tennessee	W	W	--	--	W	W
Texas	4	W	W	W	524	3,840
Utah	--	--	--	--	189	1,190
Vermont	W	W	--	--	W	W
Virginia	22,200	127,000	12,700	71,800	1,330	7,460
Washington	234	1,030	10,700	47,900	W	W
West Virginia	--	--	--	--	2,070	14,100
Wisconsin	1,200	2,340	W	W	W	W
Wyoming	3,410	W	--	--	W	W
Other	7,990	97,800	9,780	59,900	11,600	72,400
Total	178,000	1,120,000	91,000	576,000	34,300	212,000

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Data derived in part from the Alaska Geological Survey.

TABLE 11

CRUSHED VOLCANIC CINDER AND SCORIA AND CRUSHED MISCELLANEOUS STONE 1/ SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY STATE 2/

(Thousand metric tons and thousand dollars)

State	Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value
Alabama	--	--	W	W
Alaska 3/	--	--	2,480	18,000
Arizona	45	94	W	W
Arkansas	--	--	1,580	10,200
California	487	2,100	4,960	32,800
Colorado	W	W	W	W
Florida	--	--	1,820	7,930
Georgia	--	--	W	W
Hawaii	143	1,080	876	9,650
Idaho	W	W	679	3,520
Illinois	--	--	W	W
Iowa	--	--	W	W
Louisiana	--	--	W	W
Maine	--	--	W	W
Maryland	--	--	W	W
Massachusetts	--	--	W	W
Michigan	--	--	W	W
Mississippi	--	--	26	203
Montana	5	12	W	W
Nevada	54	W	W	W
New Mexico	285	2,000	W	W
New York	--	--	W	W
North Carolina	W	W	3,590	24,700
Oklahoma	--	--	W	W
Oregon	W	W	2,650	13,700
Pennsylvania	--	--	5,310	29,300
South Carolina	--	--	3,220	W
South Dakota	--	--	W	W
Tennessee	--	--	W	W
Texas	W	W	2,630	6,530
Utah	4	4	--	--
Vermont	--	--	W	W
Virginia	--	--	563	W
Washington	W	W	475	2,560
Wyoming	W	W	W	W
Other	1,030	7,320	5,430	52,000
Total	2,060	12,600	36,300	211,000

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Includes marl, shell, slate, and other stone.

2/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Data derived in part from the Alaska Geological Survey.

TABLE 12
KIND OF CRUSHED STONE PRODUCED IN THE UNITED STATES IN 1994, BY STATE

State	Limestone	Dolomite	Marble	Marl	Shell	Granite	Traprock	Sandstone	Quartzite	Slate	Volcanic cinder and scoria	Miscellaneous
Alabama	X	X	X			X				X		
Alaska 1/						X	X	X		X		X
Arizona	X		X			X	X	X	X		X	X
Arkansas	X	X				X	X	X				X
California	X	X			X	X	X	X	X	X	X	X
Colorado	X					X		X			X	X
Connecticut	X	X				X	X					
Florida	X	X		X	X							
Georgia	X		X	X		X			X			
Hawaii	X						X				X	X
Idaho	X				X	X	X		X		X	X
Illinois	X	X										X
Indiana	X	X										
Iowa	X	X										X
Kansas	X							X	X			
Kentucky	X							X				
Louisiana					X			X				X
Maine	X			X		X	X			X		X
Maryland	X					X	X	X				X
Massachusetts	X	X				X	X					X
Michigan	X	X		X			X	X				X
Minnesota	X	X				X	X	X	X			
Mississippi	X			X								
Missouri	X	X				X		X				
Montana	X					X	X	X	X		X	X
Nebraska	X											
Nevada	X	X				X	X				X	X
New Hampshire	X					X	X					
New Jersey	X					X	X	X				X
New Mexico	X					X	X	X	X		X	X
New York	X	X	X			X	X	X		X		
North Carolina	X	X		X		X	X		X	X	X	X
Ohio	X	X						X				
Oklahoma	X	X				X	X	X		X		X
Oregon	X				X	X	X	X	X	X	X	X
Pennsylvania	X	X	X			X	X	X	X			X
Rhode Island	X					X	X					
South Carolina	X		X	X		X						
South Dakota	X								X			X
Tennessee	X	X				X		X				X
Texas	X	X	X	X		X	X	X			X	X
Utah	X	X						X	X		X	
Vermont	X	X	X			X			X	X		
Virginia	X	X				X	X	X	X	X		X
Washington	X	X	X			X	X	X			X	X
West Virginia	X	X						X				
Wisconsin	X	X				X	X	X	X			
Wyoming	X		X			X			X		X	X

1/ Data derived in part from the Alaska Geological Survey.

TABLE 13
CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY USE 1/

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Coarse aggregate (+1 1/2 inch):			
Macadam	5,260	$26,500	$5.05
Riprap and jetty stone	23,300	127,000	5.44
Filter stone	7,780	42,200	5.43
Other coarse aggregate	7,450	40,700	5.46
Coarse aggregate, graded:			
Concrete aggregate, coarse	112,000	627,000	5.58
Bituminous aggregate, coarse	89,600	511,000	5.70
Bituminous surface-treatment aggregate	21,300	128,000	6.00
Railroad ballast	16,300	88,100	5.41
Other graded coarse agggregate	24,100	141,000	5.84
Fine aggregate (-3/8 inch):			
Stone sand, concrete	23,100	130,000	5.63
Stone sand, bituminous mix or seal	23,800	128,000	5.37
Screening, undesignated	29,700	141,000	4.75
Other fine aggregate	4,550	26,800	5.89
Coarse and fine aggregates:			
Graded road base or subbase	181,000	800,000	4.41
Unpaved road surfacing	29,200	139,000	4.75
Terrazzo and exposed aggregate	2,430	20,600	8.48
Crusher run or fill or waste	48,400	209,000	4.32
Other coarse and fine aggregates	27,700	160,000	5.77
Roofing granules	4,230	48,500	11.47
Other construction materials 2/	10,600	66,000	6.25
Agricultural:			
Agricultural limestone	13,600	91,400	6.73
Poultry grit and mineral food	2,040	27,100	13.26
Other agricultural uses	1,280	6,790	5.29
Chemical and metallurgical:			
Cement manufacture	85,200	303,000	3.55
Lime manufacture	17,800	92,800	5.21
Dead-burned dolomite manufacture	526	1,680	3.20
Flux stone	4,990	26,700	5.36
Chemical stone	779	3,800	4.88
Glass manufacture	680	7,150	10.52
Sulfur oxide removal	2,680	13,300	4.96
Special:			
Mine dusting or acid water treatment	479	9,070	18.94
Asphalt fillers or extenders	1,780	16,900	9.53
Whiting or whiting substitute	1,810	75,500	41.71
Other fillers or extenders	4,500	98,700	21.95
Other miscellaneous uses:			
Abrasives	W	W	6.13
Flour (slate)	W	W	44.09
Sugar refining	W	W	10.18
Other specified uses not listed 3/	1,660	10,900	5.70
Unspecified: 4/			
Actual	263,000	1,470,000	5.59
Estimated	133,000	766,000	5.75
Total	1,230,000	6,620,000	5.39

W Withheld to avoid disclosing company proprietary data; included with "Other specified uses not listed."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits, except prices; may not add to totals shown.

2/ Includes building products, drain fields, pipe bedding and waste material.

3/ Includes disinfectant and animal sanitation, flour (slate), and sugar refining.

4/ Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 14
CRUSHED LIMESTONE 1/ AND DOLOMITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY USE 2/

(Thousand metric tons and thousand dollars)

Use	Limestone		Dolomite	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1 1/2 inch):				
Macadam	2,100	9,820	1,420	6,860
Riprap and jetty stone	16,400	78,500	1,230	6,960
Filter stone	5,420	27,400	193	1,240
Other coarse aggregate	3,910	19,200	319	1,510
Coarse aggregate, graded:				
Concrete aggregate, coarse	73,700	384,000	13,100	69,500
Bituminous aggregate, coarse	54,400	282,000	11,300	64,200
Bituminous surface-treatment aggregate	13,600	73,100	2,350	14,400
Railroad ballast	4,510	19,300	1,740	8,010
Other graded coarse aggregate	11,200	59,900	5,870	29,100
Fine aggregate (-3/8 inch):				
Stone sand, concrete	13,900	72,500	3,920	16,900
Stone sand, bituminous mix or seal	14,800	71,200	3,000	17,900
Screening, undesignated	18,600	84,000	2,230	11,300
Other fine aggregate	2,270	11,600	680	4,420
Coarse and fine aggregates:				
Graded road base or subbase	118,000	485,000	16,000	73,200
Unpaved road surfacing	16,500	84,800	6,300	26,400
Terrazzo and exposed aggregate	1,460	9,880	73	289
Crusher run or fill or waste	29,500	121,000	3,360	11,400
Other coarse and fine aggregates	14,000	67,200	5,000	29,000
Roofing granules	397	3,600	--	--
Other construction materials 3/	3,890	21,900	315	1,540
Agricultural:				
Agricultural limestone	11,500	73,400	2,120	18,100
Poultry grit and mineral food	1,910	25,800	9	137
Other agricultural uses	620	3,040	165	1,270
Chemical and metallurgical:				
Cement manufacture	81,400	278,000	W	W
Lime manufacture	15,500	82,000	2,320	9,680
Dead-burned dolomite manufacture	151	374	376	1,310
Flux stone	2,170	9,770	2,190	10,900
Chemical stone	777	3,790	W	W
Glass manufacture	654	6,720	W	W
Sulfur oxide removal	2,630	13,100	W	W
Special:				
Mine dusting or acid water treatment	347	5,560	W	W
Asphalt fillers or extenders	1,040	11,500	686	4,950
Whiting or whiting substitute	1,650	68,100	W	W
Other fillers or extenders	3,080	72,400	379	5,400
Other miscellaneous uses:				
Abrasives	W	W	--	--
Sugar refining	W	W	--	--
Other uses not listed 4/	1,300	6,790	127	2,120
Unspecified: 5/				
Actual	158,000	822,000	3,350	19,700
Estimated	86,900	474,000	2,540	11,800
Total	788,000	3,940,000	92,700	479,000

W Withheld to avoid disclosing company proprietary data; included with "Other uses not listed."

1/ Includes a minor amount of limestone-dolomite reported without a distinction between the two.

2/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes building products, drain fields, pipe bedding, and waste material.

4/ Includes disinfectant and animal sanitation.

5/ Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 15
CRUSHED LIMESTONE 1/ AND DOLOMITE SOLD OR USED BY PRODUCERS IN 1994, BY STATE AND USE 2/

(Thousand metric tons and thousand dollars)

State	Concrete aggregate		Bituminous aggregate		Roadstone and coverings		Riprap and rail-road ballast		Other construction uses	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	4,320	16,900	6,050	24,400	3,590	14,600	901	4,560	4,530	19,200
Arizona	--	--	--	--	--	--	--	--	--	--
Arkansas	286	1,270	599	3,810	1,250	4,990	221	853	667	2,990
California	961	5,970	1,640	9,270	1,330	5,240	164	634	537	2,810
Colorado	--	--	--	--	--	--	--	--	W	W
Connecticut	27	W	73	W	--	--	--	--	136	W
Florida	17,000	113,000	7,740	45,200	14,700	56,300	W	W	9,940	43,700
Georgia	1,050	6,720	771	4,790	666	3,540	49	383	1,400	8,310
Hawaii	205	2,520	--	--	107	1,260	W	W	337	3,630
Idaho	--	--	--	--	--	--	--	--	--	--
Illinois	6,660	34,000	6,930	41,400	12,800	57,000	1,020	5,640	1,490	6,360
Indiana	5,290	20,600	5,100	21,000	7,370	34,200	1,440	6,280	2,720	12,400
Iowa	1,200	8,510	1,790	9,540	5,650	31,000	342	2,130	768	3,790
Kansas	844	4,960	1,180	7,320	2,940	13,400	W	W	2,000	10,400
Kentucky	4,010	19,500	9,310	44,700	11,500	51,600	4,710	19,900	7,000	27,200
Maine	W	825	--	--	--	--	--	--	--	--
Maryland	2,330	12,700	3,650	24,300	1,850	12,100	W	W	3,130	20,900
Massachusetts	--	--	W	W	W	W	--	W	W	W
Michigan	5,810	18,400	4,250	13,000	4,110	15,000	276	1,730	580	1,920
Minnesota	333	1,480	366	1,470	2,370	8,910	115	558	442	2,260
Mississippi	W	W	W	W	W	W	W	W	W	W
Missouri	3,730	25,800	4,220	22,700	13,800	57,900	4,350	15,000	4,340	20,400
Montana	--	--	--	--	--	--	W	W	--	9
Nebraska	763	5,400	W	W	526	3,770	271	2,240	705	4,250
Nevada	--	--	--	--	W	W	--	--	--	--
New Hampshire	W	W	--	--	--	--	W	W	--	--
New Jersey	W	W	W	W	W	W	--	--	W	W
New Mexico	261	1,290	97	129	229	380	W	W	58	160
New York	2,990	22,200	11,000	71,700	6,290	34,200	524	3,280	6,370	28,100
North Carolina	141	1,090	W	W	175	1,010	48	336	460	2,980
Ohio	9,540	37,500	4,080	18,000	14,200	58,900	2,610	10,200	1,800	7,330
Oklahoma	7,610	35,100	1,410	7,120	1,700	6,250	911	5,390	6,520	21,700
Oregon	--	--	--	--	--	--	--	--	--	--
Pennsylvania	6,610	38,300	14,000	86,500	11,900	61,900	811	5,090	6,560	38,200
Rhode Island	--	--	--	--	--	--	--	--	3	W
South Carolina	--	--	--	--	--	--	--	--	--	--
South Dakota	W	W	W	W	W	W	W	W	W	W
Tennessee	4,870	25,200	14,700	78,200	12,000	59,700	1,690	8,390	7,310	36,600
Texas	15,700	73,200	10,800	47,100	20,700	61,300	835	4,670	4,350	12,200
Utah	--	--	W	W	W	W	W	W	W	W
Vermont	76	418	W	W	153	769	--	--	W	W
Virginia	2,020	12,000	2,540	15,600	2,690	13,400	535	3,270	3,680	18,500
Washington	--	W	9	W	--	W	W	W	W	W
West Virginia	1,030	5,860	2,680	14,500	787	4,530	437	2,450	3,300	17,900
Wisconsin	1,400	6,180	1,310	5,920	7,560	27,900	W	W	1,300	5,560
Wyoming	W	W	W	W	W	W	W	W	W	W
Total	107,000	557,000	116,000	618,000	163,000	701,000	22,300	103,000	82,400	380,000
Total withheld	376	1,760	1,760	9,960	1,600	5,540	1,630	9,840	1,980	10,500
Grand total	107,000	559,000	118,000	628,000	165,000	706,000	23,900	113,000	84,400	390,000

See footnotes at end of table.

TABLE 15-Continued
CRUSHED LIMESTONE 1/ AND DOLOMITE SOLD OR USED BY PRODUCERS IN 1994, BY STATE AND USE 2/

(Thousand metric tons and thousand dollars)

State	Cement manufacture		Agricultural uses		Lime manufacture		Other uses		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	W	W	1,400	7,270	9,790	42,900	30,600	130,000
Arizona	W	W	W	W	--	--	2,710	10,500	2,710	10,500
Arkansas	W	W	255	2,410	W	W	4,840	22,100	8,120	38,400
California	12,600	43,900	W	W	W	W	6,250	82,300	23,500	150,000
Colorado	1,280	6,550	--	--	--	--	W	W	2,550	13,900
Connecticut	--	--	29	W	--	--	1,580	19,600	1,850	19,600
Florida	W	W	951	8,500	--	--	14,800	68,900	65,100	335,000
Georgia	W	W	W	W	--	--	W	W	5,090	31,000
Hawaii	278	2,170	W	W	--	--	73	884	1,000	10,500
Idaho	W	W	W	W	--	--	407	1,400	407	1,400
Illinois	2,130	7,540	2,300	10,900	--	--	29,200	190,000	62,600	353,000
Indiana	3,510	6,110	1,410	6,010	--	--	19,000	105,000	45,900	211,000
Iowa	2,810	20,100	1,190	10,600	W	W	22,900	125,000	36,600	211,000
Kansas	W	W	209	931	--	--	13,400	61,500	20,600	98,500
Kentucky	W	W	1,540	7,310	W	W	18,000	87,100	56,100	257,000
Maine	W	W	--	--	W	W	1,530	8,630	1,530	9,450
Maryland	2,030	4,670	W	W	--	--	3,880	39,600	16,900	114,000
Massachusetts	W	W	W	W	W	W	1,720	19,000	1,720	19,000
Michigan	5,980	11,400	W	W	W	W	13,700	50,800	34,700	112,000
Minnesota	--	--	167	607	--	--	4,610	19,600	8,400	34,900
Mississippi	747	W	29	215	--	--	W	W	1,870	7,290
Missouri	6,880	21,000	2,130	19,700	363	1,820	27,500	132,000	67,300	317,000
Montana	869	3,250	W	W	W	W	541	2,740	1,410	6,010
Nebraska	W	W	286	2,400	--	--	4,340	23,600	6,890	41,600
Nevada	--	--	81	1,420	W	W	1,560	13,100	1,640	14,600
New Hampshire	--	--	--	--	--	--	W	W	W	W
New Jersey	--	--	W	W	--	--	W	W	W	W
New Mexico	W	W	--	--	--	--	1,240	6,700	1,880	8,660
New York	4,150	16,200	99	912	--	--	3,500	21,600	35,000	198,000
North Carolina	--	--	10	53	--	--	W	W	4,540	31,600
Ohio	1,700	7,020	W	W	W	W	22,200	111,000	56,100	250,000
Oklahoma	W	W	W	W	--	--	6,240	23,200	24,400	98,800
Oregon	W	W	--	--	--	--	W	W	W	W
Pennsylvania	4,920	26,800	819	9,350	583	4,140	12,400	75,900	58,600	346,000
Rhode Island	--	--	9	W	--	--	W	W	W	W
South Carolina	--	--	--	--	--	--	1,610	8,710	1,610	8,710
South Dakota	W	W	--	--	W	W	W	W	2,850	9,520
Tennessee	W	W	708	5,690	W	W	7,060	47,400	48,400	261,000
Texas	9,610	23,900	483	3,050	2,780	11,600	7,080	48,600	72,300	286,000
Utah	W	W	W	W	W	W	4,350	18,600	4,350	18,600
Vermont	--	--	--	--	--	--	1,800	11,200	2,030	12,400
Virginia	1,480	4,920	978	12,600	1,550	6,350	4,470	30,700	19,900	118,000
Washington	--	--	W	W	W	W	2,420	24,700	2,430	24,700
West Virginia	W	W	W	W	W	W	5,620	39,900	13,800	85,200
Wisconsin	--	--	414	3,180	W	W	11,700	47,700	23,700	96,400
Wyoming	--	--	39	275	--	--	1,480	5,840	1,520	6,120
Total	61,000	205,000	14,100	106,000	6,680	31,200	295,000	1,650,000	878,000	4,410,000
Total withheld	20,400	72,800	2,170	15,700	11,600	62,200	9,990	66,300	2,030	14,900
Grand total	81,400	278,000	16,300	122,000	18,300	93,400	XX	XX	881,000	4,420,000

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Other uses." XX Not applicable.

1/ Includes a minor amount of limestone-dolomite reported without a distinction between the two.

2/ Data rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 16
CRUSHED MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY USE 1/

(Thousand metric tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1 1/2 inch):		
Riprap and jetty stone	23	250
Filter stone	(2/)	3
Coarse aggregate, graded:		
Bituminous aggregate, coarse	136	938
Other graded coarse aggregate	9	155
Coarse and fine aggregates:		
Unpaved road surfacing	2	13
Terrazzo and exposed aggregate	88	2,690
Roofing granules	1	25
Other construction materials 3/	888	6,060
Chemical and metallurgical:		
Lime manufacture	50	1,100
Other specified uses not listed 4/	1,550	33,300
Unspecified: 5/		
Actual	1,000	7,300
Estimated	2,340	13,300
Total	6,090	65,100

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Includes concrete aggregate (coarse), bituminous surface treatment aggregate, screening-undesignated, graded roadbase or subbase, and crusher run (select material or fill).

4/ Includes mine dusting or acid water, other agricultural uses, other fillers or extenders, and whiting or whiting substitute.

5/ Includes production reported without a breakdown by end use and estimates for responde

TABLE 17
CRUSHED GRANITE AND TRAPROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY USE 1/

(Thousand metric tons and thousand dollars)

Use	Granite		Traprock	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1 1/2 inch):				
Macadam	1,540	8,380	187	1,470
Riprap and jetty stone	3,350	25,700	1,370	10,300
Filter stone	1,080	7,220	649	3,980
Other coarse aggregate	1,350	7,970	1,480	9,380
Coarse aggregate, graded:				
Concrete aggregate, coarse	15,800	107,000	7,150	52,200
Bituminous aggregate, coarse	16,600	113,000	4,860	36,300
Bituminous surface-treatment aggregate	2,150	19,100	2,210	14,200
Railroad ballast	7,670	46,600	1,860	11,100
Other graded coarse aggregate	4,190	29,300	2,210	18,600
Fine aggregate (-3/8 inch):				
Stone sand, concrete	2,880	19,800	1,520	15,100
Stone sand, bituminous mix or seal	3,750	21,700	1,570	12,800
Screening, undesignated	4,850	23,700	2,710	15,300
Other fine aggregate	1,100	7,320	452	3,210
Coarse and fine aggregates:				
Graded road base or subbase	20,300	107,000	15,500	79,600
Unpaved road surfacing	1,460	4,890	3,340	13,800
Terrazzo and exposed aggregate	302	2,230	(2/)	(2/)
Crusher run or fill or waste	11,100	52,600	2,810	16,600
Other coarse and fine aggregates	2,670	20,600	4,880	37,000
Roofing granules	2,350	25,700	(2/)	(2/)
Other construction materials	2,280	16,600	3,030 3/	25,800 3/
Agricultural:				
Poultry grit and mineral food	(4/)	(4/)	--	--
Other agricultural uses	293	650	--	--
Special:				
Asphalt fillers or extenders	(5/)	(5/)	--	--
Other fillers or extenders	--	--	(5/)	(5/)
Other uses not listed	18	295	99	854
Unspecified: 6/				
Actual	61,600	394,000	16,300	94,100
Estimated	9,380	58,900	16,700	104,000
Total	178,000	1,120,000	91,000	576,000

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Included with "Other construction materials."

3/ Includes pipe bedding.

4/ Included with "Other agricultural uses."

5/ Included with "Other uses not lised."

6/ Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 18
CRUSHED SANDSTONE AND QUARTZITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY USE 1/

(Thousand metric tons and thousand dollars)

Use	Sandstone		Quartzite	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1 1/2 inch):				
Macadam	W	W	--	--
Riprap and jetty stone	558	3,240	196	1,040
Filter stone	253	1,440	34	190
Other coarse aggregate	34	235	112	629
Coarse aggregate, graded:				
Concrete aggregate, coarse	1,620	9,260	330	2,000
Bituminous aggregate, coarse	1,460	9,790	271	1,360
Bituminous surface-treatment aggregate	700	5,310	79	480
Railroad ballast	93	519	323	1,740
Other graded coarse aggregate	202	1,310	173	900
Fine aggregate (-3/8 inch):				
Stone sand, concrete	755	5,120	153	605
Stone sand, bituminous mix or seal	513	2,980	116	630
Screening, undesignated	966	5,360	78	375
Other fine aggregate	W	W	--	--
Coarse and fine aggregates:				
Graded road base or subbase	3,880	17,600	509	2,630
Unpaved road surfaces	417	3,220	205	905
Terrazzo and exposed aggregate	72	862	8	129
Crusher run or fill or waste	1,000	4,630	68	393
Other coarse and fine aggregates	600	3240	204 2/	904 2/
Other construction materials	91	434	--	--
Agricultural:				
Other agricultural uses	--	--	1	6
Chemical and metallurgical:				
Cement manufacture	821	4,480	171	1,220
Flux stone	--	--	632	6,060
Glass manufacture	--	--	(3/)	(3/)
Special:				
Mine dusting or acid water treatment	(3/)	(3/)	--	--
Asphalt fillers or extenders	(3/)	(3/)	--	--
Other uses not listed 4/	124	822	54	696
Unspecified: 5/				
Actual	8,730	56,700	2,880	16,600
Estimated	4,550	34,100	231	1,570
Total	27,400	171,000	6,830	41,100

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes pipe bedding.

3/ Included with "Other uses not listed."

4/ Includes poultry grit and mineral food.

5/ Includes production reported without breakdown by end use and estimates for nonrespondents.

TABLE 19
CRUSHED VOLCANIC CINDER AND SCORIA AND CRUSHED MISCELLANEOUS STONE 1/ SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY USE 2/

(Thousand metric tons and thousand dollars)

Use	Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1 1/2 inch):				
Riprap and jetty stone	9	40	135	509
Filter stone	101	454	48	246
Other coarse aggregate	46	252	199	1,310
Course aggregate, graded:				
Concrete aggregate, coarse	119	493	457	1,900
Bituminous aggregate, coarse	6	35	572	2,750
Bituminous surface-treatment aggregate	--	--	8	39
Railroad ballast	--	--	W	W
Other graded coarse aggregate	--	--	238	1,400
Fine aggregate (-3/8 inch):				
Stone sand, concrete	13	171	W	W
Stone sand, bituminous mix or seal	--	--	61	304
Screening, undesignated	1	9	304	797
Coarse and fine aggregates:				
Graded road base or subbase	362	1,680	6,480	28,700
Unpaved road surfacing	87	207	931	4,380
Terrazzo and exposed aggregate	266	2,650	140	1,360
Crusher run or fill or waste	83	327	381	689
Other coarse and fine aggregates	--	--	379	1,790
Roofing granules	W	W	492	6,420
Other construction materials	73	453	1,900	10,300
Agricultural:				
Poultry grit and mineral food	--	--	(3/)	(3/)
Other agricultural uses	38	333	41	244
Chemical and metallurgical:				
Cement manufacture	--	--	2,840	17,200
Other specified uses not listed	61	602	42 4/	764 4/
Unspecified: 5/				
Actual	750	4,640	10,200	53,000
Estimated	44	261	10,400	68,600
Total	2,060	12,600	36,300	211,000

W Withheld to avoid disclosing company proprietary data; included with "Other construction materials" and/or "Total."

1/ Includes marl, shell, slate, and other stone.

2/ Data rounded by U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Included with "Other specified uses not listed."

4/ Includes flour (slate).

5/ Includes production reported without a breakdown by end use and estimates for nonrespondents.

TABLE 20
CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1994, BY REGION AND METHOD OF TRANSPORTATION 1/

(Thousand metric tons)

Region	Truck	Rail	Water	Other	Not transported	Not specified	Total
Northeast:							
New England	9,450	491	(2/)	(2/)	2,220	13,900	26,100
Middle Atlantic	80,300	1,700	3,810	719	15,200	34,200	136,000
Midwest:							
East North Central	99,200	6,180	26,500	715	13,300	83,800	230,000
West North Central	59,500	2,130	7,490	7	11,000	70,200	150,000
South:							
South Atlantic	138,000	14,200	4,240	153	21,100	115,000	293,000
East South Central	78,400	3,530	12,500	1,960	9,170	34,200	140,000
West South Central	67,400	21,000	2,400	4,190	11,300	24,000	130,000
West:							
Mountain	14,400	4,190	(2/)	1,490	2,350	13,400	35,800
Pacific	34,900	1,470	377	10,500	5,300	35,100	87,600
Total	582,000	54,900	57,300	19,700	91,000	424,000	1,230,000

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

TABLE 21
NUMBER OF CRUSHED AND BROKEN STONE OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 1994, BY STATE 1/

State	Mining operations on land					
	Stationary	Portable	Stationary and portable	No. plants or unspecified	Dredging operations	Total active operations
Alabama	37	3	--	1	--	41
Alaska 2/	3	11	1	7	--	21
Arizona	16	7	2	7	1	33
Arkansas	26	8	2	5	--	41
California	59	29	9	31	1	129
Colorado	6	6	6	7	--	25
Connecticut	15	2	--	--	--	17
Florida	35	28	7	11	5	86
Georgia	66	2	--	3	--	71
Hawaii	19	8	3	6	--	36
Idaho	6	35	5	3	--	49
Illinois	86	53	10	5	--	154
Indiana	71	4	4	1	--	80
Iowa	23	198	--	6	2	229
Kansas	18	87	2	4	--	111
Kentucky	79	5	2	6	--	92
Louisiana	1	--	--	4	3	8
Maine	6	6	1	2	--	15
Maryland	22	7	2	2	--	33
Massachusetts	23	5	3	4	--	35
Michigan	18	12	1	4	2	37
Minnesota	10	33	1	12	--	56
Mississippi	4	1	--	--	--	5
Missouri	94	95	8	12	--	209
Montana	11	4	--	1	--	16
Nebraska	6	4	2	--	--	12
Nevada	10	6	2	--	--	17
New Hampshire	7	2	1	2	--	12
New Jersey	12	1	8	--	--	21
New Mexico	21	21	2	4	--	48
New York	64	12	15	11	--	102
North Carolina	85	7	4	3	--	99
Ohio	82	17	6	2	1	108
Oklahoma	42	6	7	2	--	57
Oregon	33	89	7	20	1	150
Pennsylvania	130	24	20	23	--	197
Rhode Island	7	--	--	--	--	7
South Carolina	28	1	1	1	--	31
South Dakota	10	--	1	--	--	11
Tennessee	104	6	4	2	--	116
Texas	62	47	13	5	1	128
Utah	9	11	1	--	--	21
Vermont	7	6	2	4	--	19
Virginia	91	5	5	--	--	100
Washington	30	60	5	27	--	121
West Virginia	28	10	2	2	--	42
Wisconsin	25	134	--	19	--	176
Wyoming	8	6	--	--	--	14
Total	1,660	1,120	177	271	17	3,240

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Data derived in part from the Alaska Geological Survey.

TABLE 22
U.S. EXPORTS OF CRUSHED STONE IN 1994, BY DESTINATION 1/

(Metric tons)

Destination	Limestone for cement manufacturing	Other	Chalk, crude	Granules, chippings	Total
North America:					
Aruba	--	--	--	2	2
Bahamas, The	198	--	--	--	198
Barbados	--	--	27	--	27
Bermuda	37	--	--	--	37
British Virgin Islands	9	--	--	--	9
Canada	4,380,000	277	1,970	168,000	4,550,000
Cayman Islands	--	--	--	323	323
Jamaica	7,680	--	--	16	7,700
Mexico	2,300	235	462	5,340	8,340
Netherlands Antilles	--	--	--	1	1
Panama	--	--	54	461	515
Trinadad and Tobago	--	--	18	--	18
Total	4,390,000	512	2,530	174,000	4,570,000
South America:					
Argentina	20	--	1	61	82
Brazil	6,650	63	--	--	6,710
Colombia	--	5	--	20	25
Ecuador	--	--	92	2	94
Guyana	--	--	2	--	2
Venezuela	920	18	37	36	1,010
Total	7,590	86	132	119	7,930
Europe:					
Austria	4,700	--	--	--	4,700
Belgium	50,700	--	--	--	50,700
Denmark	180	--	--	--	180
Finland	--	--	--	21	21
France	11,700	71	12	61	11,900
Germany	161,000	2,230	--	276	163,000
Greece	--	--	--	32	32
Hungary	1,680	--		--	1,680
Ireland	416	374	--	--	790
Italy	96,700	47	--	45	96,800
Netherlands	900	221	6	34	1,160
Norway	--	--	4	--	4
Poland	--	146	--	--	146
Russia	--	--	--	22	22
Spain	--	12	--	--	12
Sweden	8,100	1	--	--	8,100
Switzerland	2,100	23	--	121	2,240
United Kingdom	75,800	55	30	121	76,000
Total	414,000	3,180	51	733	418,000
Asia:					
China	35,600	14	132	--	35,700
Hong Kong	132	40	1	19	192
Indonesia	20,900	11	--	--	20,900
Japan	79,000	90	2	519	79,600
Korea, Republic of	5,400	25	--	757	6,180
Malaysia	160	49	--	33	242
Philippines	73	--	12	--	85
Singapore	--	28	--	57	85
Sri Lanka (Ceylon)	18	--	--	34	52
Taiwan	31,800	19	--	108	31,900
Thailand	820	--	16	--	836
Total	174,000	276	163	1,530	176,000

See footnotes at end of table.

TABLE 22 - CONTINUED
U.S. EXPORTS OF CRUSHED STONE IN 1994, BY DESTINATION

(Metric tons)

Destination	Limestone for cement manufacturing	Other	Chalk, crude	Granules, chippings	Total
Oceania:					
Australia	4,790	1	131	79	5,000
Total	4,790	1	131	79	5,000
Middle East:					
Israel	--	604	95	--	699
Saudi Arabia	68	--	--	139	207
United Arab Emirates	--	--	--	11	11
Total	68	604	95	150	917
Africa:					
Egypt	--	--	10	611	621
Total	--	--	10	611	621
Grand total	4,990,000	4,660	3,110	177,000	5,180,000
Total value (thousands)	$25,300	$3,820	$1	$9,010	$38,100

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: U.S. Bureau of the Census.

TABLE 23
U.S. IMPORTS OF CRUSHED STONE AND CALCIUM CARBONATE FINES, BY TYPE 1/

(Thousand metric tons and thousand dollars)

Type	1993		1994		
	Quantity	C.i.f. value 2/	Quantity	C.i.f. value 2/	Unit price
Crushed stone and chips:					
Limestone 2/	4,980	41,100	5,100	41,500	$8
Limestone for flux or cement manufacturing	3,070	21,400	3,250	23,800	$7
Quartzite	(2/)	343	(2/)	156	$591
Other	353	6,230	583	9,030	$15
Total	8,400	69,000	8,930	74,500	XX
Calcium carbonate fines: 3/					
Natural chalk	(4/)	255	(4/)	1,940	$8,160
Calcium carbonates other chalk	44	5,060	5	1,440	$300
Total	44	5,310	5	3,380	XX
Grand total	8,440	74,300	8,930	77,800	XX

XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes limestone for cement manufacturing.

3/ Excludes precipitated calcium carbonates.

4/ Less than 1/2 unit.

Source: U.S. Bureau of the Census.

DIMENSION STONE

By Harold A. Taylor, Jr.

Production of dimension stone decreased 7% to 1.19 million short tons valued at $218 million. More than one-half of the dimension stone produced was granite. Limestone, marble, sandstone, and slate were also produced.

Exports of dimension stone increased slightly in value to $53 million. The value of dimension stone imports for consumption increased 11% to $440 million, equivalent to 202% of the value of domestic production.

Legislation and Government Programs

The Canadian International Trade Tribunal has determined that finished Indian granite monuments imported into Canada have been subsidized and are causing injury. Large duties differing from firm to firm will be put on the product of the source firms. American granite monument producers who believe they have a simliar problem noted the results with interest.

The approval of GATT will reduce duties on a number of items; table 2 reflects these new duties. The reductions went into effect January 1, 1995.

Production

Dimension stone was produced by 172 companies at 257 quarries in 36 States. Leading States, in order of tonnage, were Indiana, Georgia, and Vermont, together producing 44% of the Nation's total. Of the total production, 42% was granite, 31% was limestone, 14% was sandstone, 3% was slate, 3% was marble, and the remaining 7% was miscellaneous stone. Miscellaneous stone included quartzite argillite, schist, soapstone, and traprock (basalt). Leading producing companies in terms of tonnage were Cold Spring Granite Co., principally in California, Minnesota, South Dakota, and Texas; Rock of Ages Corp. in New Hampshire and Vermont; and Fletcher Granite Co. Inc. in Massachusetts and New Hampshire.

Granite.—Dimension granite includes all coarse-grained igneous rocks. Production decreased 20% to 499,000 tons and decreased 18% in value to $90.07 million in 1994. Granite was produced by 59 companies at 97 quarries in 19 States. Georgia continued to be the leading State, producing 38% of the U.S. total, followed by Massachusetts and Vermont. These three States together produced about 60% of the U.S. total. Cold Spring Granite, Rock of Ages, and Fletcher Granite Co. were the leading producers and accounted for 37% of U.S. production.

Limestone.—Dimension limestone includes bituminous, dolomitic, and siliceous limestones. Indiana, the leading State, produced 173,000 tons in 1994, Wisconsin, as the second largest producer, and Kansas as the third largest.

The assets of Alabama Limestone have been seized by AmSouth Bank and put up for sale. The assets were collateral for a $1.5-million debt. They include 364 hm^2 (900 acres) of land with limestone reserves, an underground quarry and equipment and a finishing plant with 11 operational gangsaws.[1]

Sandstone.—Dimension sandstone includes calcareous- and siliceous-cemented sandstones or conglomerates. Quartzite may be described as any siliceous-cemented sandstone. In 1993, the U.S. total for sandstone 138,000 tons valued at $13.8 million (revised), Pennsylvania produced 26,400 tons of sandstone valued at $3.6 million (revised), New York produced 20,500 tons of sandstone valued at $5,000,000 (revised), and Utah and Arizona combined totaled 76,700 tons valued at $3.5 million, and in 1992 they totaled 27,700 tons valued at $2.2 million.

In addition to the quantities shown in table 7, dimension quartzite totaled 57,100 tons worth $5,266,000 in 1994 and 27,700 tons worth $2.7 million in 1992. Utah and Idaho combined totaled 14,400 tons valued at $1,260,000 in 1994, and 7,850 tons worth $720,000 in 1992.

Classic portland brownstone has become available after many years' absence. The portland brownstone is being shipped from a quarry in Cheshire, CT. The owners expect to produce more than 566m^3/a (20,000 cu ft/year), mostly for restoration projects. (See tables 3 and 4.)

Domestic production data for dimension stone are developed by the U.S. Bureau of Mines from voluntary surveys of U.S. producers of rough and finished dimension stone. Of the 324 dimension stone operations surveyed for 1994, including those that were idle, 255, or 79%, responded, representing 89% of the estimated value shown in table 1.

Consumption and Uses

Dimension stone was marketed over wide areas. Industry stockpiles were not monitored, and production during the year was assumed to equal consumption.

Consumption of domestic dimension stone decreased 7% to 1.19 million tons valued at $218 million tons valued at $226.0 million (revised) in 1993 and 1.14 million tons valued at $198.0 million in 1992.

Consumption of domestic granite decreased to 499,000 tons valued at $90.7 million in 1994 compared with 525,000 tons valued at $85.0 million in 1993.

The black granite of the Vietnam Veteran's Memorial in Washington, DC is developing cracks. After first appearing 11 years, some of the cracks are now 230 mm (9 in.) long. A firm has been hired to study the cracks, develop a maintenance plan and locate a source for replacement stone. A Korean War Veterans Memorial made of Academy black granite from California is in the last stages of planning.

Consumption of domestic limestone was 366,000 tons valued at $58.5 million in 1994 compared with 375,000 tons valued at $50.1 million (revised) in 1993.

Consumption of domestic marble, including travertine, totaled 36,300 tons valued at $20.7 million in 1994 compared with 29,880 tons valued at $26.5 million in 1993.

Consumption of domestic dimension sandstone was 172,000 tons valued at $15.6 million in 1994, compared with 138,300 (revised) tons valued at $13.8 million in 1993. In 1993 (revised), flagging totaled 42,700 tons valued at $5.0 million and other dressed sandstone totaled 13,400 tons valued at $2.8 million.

Consumption of domestic slate totaled 35,200 tons valued at $23.2 million in 1994 compared with 26,800 tons valued at $16.7 million in 1993. *(See tables 5, 6, 7, 8, 9, and 10.)*

Prices

The average price for dimension stone increased to $183 per ton, up slightly from $177 in 1993.

Dimension stone is a natural rock material that has been selected, trimmed, or cut to specified or indicated shapes or sizes, with or without one or more mechanically dressed surfaces. This includes rough stone, rubble, ashlar, blocks, panel, and curvilinear shapes. Finished surface requirements may vary from a controlled fractured surface to ground and polished. The most prominent required qualities of dimension stone are strength, toughness, hardness, and resistance to environmmental damage. Color and grain structure contribute largely to price and marketability. The principal types of dimension stone used in construction are granite, marble, limestone, sandstone, and slate.

Stone classification by type in the dimension stone industry is somewhat ambiguous and does not correspond in some respects with the same terms used in mineralological rock descriptions. The U.S. Bureau of Mines generally accepts the classification reported by producers. Granite includes all feldspathic crystalline rocks of predominantly interlocking texture with mineral grains visible to the naked eye; these include igneous and metamorphic rocks, including quartz diorites, syenites, quartz porphyries, gabbros, anorthosites, and gneisses. White, gray, black, pink, and red are the common colors for granite, but greens, browns, and other shades are produced in some localities.

Limestone includes dolomitic types as well as calcitic. The latter contain less than 5% magnesium carbonate ($MgCO_3$). Dolomitic limestone contains 5% to 40% $MgCO_3$. Marble is a recrystallized (metamorphosed) limestone containing grains of calcite or dolomite or both. In commercial usage, it is any calcareous crystalline rock or serpentine, a hydrous magnesium silicate, capable of taking a polish. Travertine is a type of marble similar to onyx except that it is precipated from warm or hot water; it has a banded cellular structure and contains cavities up to one-half inch in width that are lined with microstalactites. Dark green serpentines are classified as marble in the industry because they are often crisscrossed with marblelike veinlets of lighter materials, chiefly calcity or dolomite, and because of their ability to take a high polish.

Commercial sandstone is a sedimentary rock consisting mostly of quartz, sometimes with feldspar, or rock fragments of clastic texture bonded by silica, clay, calcite, or iron oxide. Bluestone is a dense, hard, fine-grained feldspatic sandstone that splits easily along a plane into thin, smooth slabs. It is commonly dark or slate gray in color, and its name no longer has color significance. Brownstone is a feldspathic sandstone of brown reddish-brown color caused by abundant interstitial iron oxide. Flagstone may be either a sandstone or a slate that splits into large, thin slabs.

Quartzite is a metamorphic equivalent of sandstone that has been firmly cemented by secondary silica or by recrystallization so that it is essentially homogeneous and fractures through rather than around the original sand grains.

Slate is a fine-grained metamorphic rock derived from shale, siltstone, or claystone. It has prominent cleavage that is oriented independently from the original sedimentary bedding. Mineral constituents are quartz, mica, sericite, or chlorite with assorted minor accessories. Shale is composed mostly of original clay minerals, and cleavage is parallel to the bedding.

Traprock is a commercial term for all dark, igneous rocks too fine in grain size to be called black granite. In addition to extrusive flow rocks such as basalt, andesite, or dacite, traprock includes intrusive igneous rocks such as diabase, diorites, gabbros, pyroxenites, amphibolites, and peridotites.

Miscellaneous stones used for dimension purposes include schist, scoria, soapstone, wollastonite, argillite, and many others.

Geology-Resources

Domestic resources of most types of dimension stone used in construction are practically unlimited. There is considerable interstate transportation of certain types of stone such as Indiana limestone, Georgia marble and granite, and Vermont granite, marble, and slate. A lack of deposits of certain specific varieties of dimension stone especially noted for their esthetic qualities in architecture and artifact manufacture is an important cause of importation of these varieties; for example, brightly colored marbles from Italy.

Technology

Mining.—Present mining methods range from antiquated and very inefficient to modern and technically superior. Quarrying methods include use of various combinations of diamond saws, wire saws, diamond wire saws, chain saws, channeling machines, drilling machines, wedges, and broaching tools. The choice of equipment depends on the type of dimension stone, size and shape of deposit, production capacity, labor costs, economics, and management investment attitudes.

Little blasting is done in the mining of dimension stone. Blocks cut from the face are sawed or split into smaller or thinner blocks for ease in transportation and handling and taken to processing plants, often at the quarry site, for final cutting and finishing operations.

Processing.—Stone-sawing equipment includes large circular saws 10 feet or more in diameter, some with diamond inserts and some using other abrasives; diamond circular saws of smaller size; and reciprocating diamond-bladed or loose-abrasive gang saws for multiple cuts. Various types of diamond and other equipment are used for smoothing, polishing, edging, and decorating the finished stone products. *(See table 2.)*

Economic Factors

The depletion allowance for dimension stone is 14%. Dimension stone quarries are generally in mountainous or hilly areas remote from areas of dense population. Because land use for other purposes is limited, the cost of land is reasonable.

Transportation costs for dimension stone are high because of its weight and because special handling methods are required to prevent damage to the finished stone. A single stone panel broken in transit not only results in the loss of the many employee-hours of skilled labor required to produce it, but also can cause construction delays that are even more costly. Nevertheless, dimension stone is routinely shipped long distances by motor and rail freight, and special domestic varieties are shipped by ocean freight to foreign countries.

Operating Factors

The dimension stone industry faced several environmentally related issues this year, primarily noise and crystalline silica. The most universal was noise pollution from the handheld burners used in many granite quarries. The operators of these burners, in particular, can be affected by the high noise level. This burner is now used only where the alternate methods using the automatic self-propelled burner, the diamond wire saw, or drill and blast with Primacord cannot be used.

Stone primary and waste products are not toxic, nor are the supplies utilized in their production. However, sufficient exposure to crystalline silica-rich stone dust can cause silicosis. The firms are required to saw with water and have employee face masks to protect against silica-containing stone dust. Water and air filtration systems specifically designed for dimension stone operations are beginning to be installed in the industry.

Although these issues were primarily or exclusively Federal in origin, other environmental requirements do vary from State to State and are often a cause of conflict between State or local governments and the quarry operators.

The dimension stone-consuming industry does recycle some postconsumer waste, and the producing industry in Vermont is trying to reduce energy and water consumption. A high proportion of granite curbing, about 80%, is recovered and reused again as curbing. Monuments, mausoleums, and tombstones stay in place for centuries, unless disturbed. However, building products usually end up in a landfill. The granite-producing industry in Vermont is conserving energy by installing more efficient lighting and motors and insulating their plants more. It is also conserving water and eliminating stream pollution by reusing clean water from their recently installed settling ponds.

The approximate number of employees in the dimension stone industry by stone kind are granite, 9,600; limestone, 1,100; marble, 1,500; slate, 950; and sandstone and other dimension stone, 850. Of the total 14,000, about 3,100 are employed in quarrying and approximately 10,900 in finishing operations. Major States for employment were Georgia with 2,100 employees, Vermont with 1,700, Minnesota with 1,250, North Carolina with 850, Texas with 700, and Indiana with 650. Fuel is used to power quarrying equipment, and electricity is used for sawing and finishing. Water is used in some quarries to cool equipment such as chain saws and in sawing and finishing plants to cool the equipment; water consumption is relatively minimal in all instances.

Annual Review

Production

Swenson Granite Co. bought the quarries of Coggins Granite Inc. of Elberton, GA, on January 29, 1992. Swenson Granite of Concord, NH, also owns Rock of Ages Corp. of Barre, VT, the major quarrier in Vermont and the owner in turn of an operation in Quebec, Rock of Ages Canada Ltd. In early 1992, Rock of Ages Canada Ltd. purchased 49.9% of Carrieres Norgranit, Inc. and a minority interest in Groupe Polycor, both Quebec granite quarriers. Rock of Ages Corp. sold its 50% interest in Whetstone Granite Co., a granite quarrier in South Dakota and Minnesota, to cowner Dakota Granite Co., while retaining some interest in quarry properties.

Coggins also sold its Chapel Rose Quarry in Oklahoma and its Radiant Red Quarry in South Carolina to Swenson Granite Co. The Georgia quarries sold include the Royalty Blue, the Berkeley Blue, and the Millstone, plus nine idle quarries and 2,800 acres of land in three Georgia counties. A few of the idle quarries may be reopened, but a finishing plant is not planned. Swenson has placed these assets with a subsidiary, Royalty Granite Corp.

Keystone Granite Co. and Childs & Childs Granite Co. Inc. formed a joint venture to buy out Matthews International's quarry division, including its North Carolina plant and quarry and two South Carolina quarries. The new venture is called Carolina Quarries Inc. and will emphasize exporting rough blocks.

Two Pacific Coast quarries were announced. One was a white granite quarry south of San Diego, CA, owned by M. W. Mihelich & Associates. The other was a black granite (gneiss) quarry in northeastern Washington owned by Black Star Stone Co. Associated finishing facilities were said to allow or shortly will allow the firms to sell polished or finished products.

Fletcher Granite Corp. tested a prototype water-jet technology for cutting stone at a quarry near Chelmsford, MA.

Marble.—Omya, Inc. began to dissolve its Vermont Marble Co. dimension marble operations late in the year. It hoped to lease its Danby White Quarry and sell its other dimension stone quarries.

Waller Bros. Stone Co. of Scioto County, OH, bought Briar Hill Stone Co. also of Ohio, from the United Bank of Canton, OH. The company is now back in production at a significant level.

A group of Canadian investors bought Cleveland Quarries Co. of Amherst, OH. It is also producing at a significant level. The investors are planning a new $5 million finishing plant that will use water-jet cutting technology. *(See tables 3 and 4.)*

Foreign Trade

Exports.—Exports of dimension stone, about 50% of which was granite, decreased 15% in value.

Imports.—Imports for consumption of dimension stone decreased 15% in value to $404 million, mostly because of decreases in imports of all major categories of dimension stone. On a value basis, marble accounted for 54% of imports, followed by granite, 29%. *(See tables 11, 12, 13, 14, and 15.)*

World Review

Some production of dimension stone occurred in most countries of the world. As usual, Italy produced about one-half of the world's total. Other significant producers were Brazil, China, Finland, India, Norway, Portugal, Spain, Sweden, Turkey, and the United States.

A major dimension stone outlook article was published by an Italian dimension stone specialist. In general, this is a time of weak economies and many uncertainties. World dimension stone production has probably topped out for a while; even hither-to fast-growing Spain had a 5% decrease in production. World dimension stone trade fell even more. It is predicted that it will get worse: dimension stone use in construction lags behind the economy. Conditions in the major markets can be summarized as follows: the Middle Eastern market has been improving along with rebuilding from the Gulf War. The American market was in the worst shape. The European market experienced moderate but slowing growth, ranging from mild negative growth for the United Kingdom to solid positive growth for Germany; Italy had no growth. Japan and the rest of the Far East had extremely strong markets.[1]

Australia.—Although the industry dates back into the 19th Century, it only became sizable in the 1980's. The most important stone is granite, the quarry production of which averages 350,000 cubic feet. Next in importance is sandstone; marble, limestone, and slate are minor. A total of 24 exporters of dimension stone are individually listed.[2]

Brazil.—The Brazilian Government published its 1991 production statistics; production of rough dimension stone in 1991 (preliminary) totaled 1.65 million tons (77% granite and 23% marble), compared with 1.42 million tons in 1990 and 1.65 million tons in 1989.

Canada.—Newfoundland Slate Inc. completed its facility at Bourgoynes Cove and began limited production this year. The plant and quarry cost about $6 million and has a capacity of 5,500 tons per year of roofing slate product. Technology for the plant and European marketing was the resposibility of Ardoisieres d'Angers SA, France's leading slate producer. The product will also be marketed in North America and Japan. The firm is one-half owned by McAsphalt Industries Ltd. of Ontario and one-half owned by a private party.

Italy.—A battle has been raging between the marble quarriers and finishers of Carrara and the local council (government) supported by the Tuscan regional administration. The government wants to develop a park in the higher elevations of the Apuan Alps behind Carrara, above approximately 4,000 feet. Quarrying is banned inside the park boundaries, and three quarries already have had to close. The marble industry is the direct and indirect source of employment for most of the local inhabitants. The council felt that the park and concurrent stronger enforcement of environmental regulations was long overdue.

Japan.—The nation's largest marble deposit has been discovered in Nyukawa, Gifu Prefecture, when it had been thought that all marble deposits were exhausted. Resources total 53.5 million tons over an area of 0.8 square mile, probably enough for 300 years of domestic consumption. The marble ranges from red to gold and is so hard that it will probably be mostly used in flooring. Quarry production is scheduled to begin in 1995 with an initial product capacity of 1,320 tons per year. Although total domestic demand is expected to grow rapidly, some displacement of European imports is likely.

The U.S. Bureau of Mines dimension stone specialist wrote an experience-based article on the huge Japanese market for granite.[3] Although the huge market for monumental granite reportedly has almost no growth, the smaller market for building granite has grown rapidly enough to catch up. Domestic production goes almost entirely to the monumental market, while rough granite imports go to both markets. Imports have been mostly rough granite, but imports of finished granite are rapidly closing the gap. Although Japanese buyers are reportedly very demanding, the expected growth makes the market very attractive to granite producers.

Spain.—A comprehensive recent article covered the fast-growing Spanish dimension stone industry.[4] Spain has very large granite and marble industries and is the world's largest exporter of slate roofing. Production in 1990 totaled 3.41 million tons, of which 1.86 million tons as block was marble, 1.09 million tons as block was granite, and 0.46 million tons was roofing slate. In addition, 1.28 million tons of other stone products was produced, almost one-half of it marble. Domestic consumption was apparently about 87% of production; by end use, 36% was consumed as paving and 22% as outdoor building cladding.

A slowdown in domestic construction began in the second half of 1991 as preparations for the Seville World's Fair and the Olympic Games were completed. The largest producers continue to be the Ingemar Group (granite and marble) and the Cupire-Padesa Group (slate). The outlook for the Spanish dimension stone industry is for much slower growth. Spain, as part of the European Committee for Standardization, is helping to prepare Europewide dimension stone standards, terminology, and test methods.

United Kingdom.—A recent article on the slate industry indicated that demand for slate in 1991 dropped drastically owing to a recession-triggered slump in construction. Domestic slate production dropped 24% while imports were halved. Penrhyn Quarries Ltd., a subsidiary of Alfred Mc Alpine PLC in Wales, remains the largest producer and, in turn, has U.S. and Irish subsidiaries. Burlington Slate Ltd. is the largest producer in the English Lake District.[5] Later in the year, both Penrhyn Quarries and Burlington Slate laid off 20% of their employees because of the worsening recession in building.

Current Research

Several helpful publications were released last year. In particular, the Marble Institute of America published The Dimension Stones of the World, Volume I. It lists the physical and chemical properties and has a colored photograph of each of many major U.S. and world stones. This volume will be of great assistance to those interested in individual stones and those in charge of selecting stones.[6]

Another publication is a bibliographic guide to the literature on dimension stone. It lists more than 270 publications on stone use in buildings, monuments, and art, plus geology, technology, history, trade names, and markets. The publications often cover only one State or quarrying area.[7]

An article describing stone selection and specification was published. It describes how to prepare a successful bid for a job, the adequate preparation leading up to it, and the painstaking followthrough that has to occur.[8]

An article pointed out that installation of thin stone veneer on buildings was not associated with an increased knowledge of stone properties. It therefore requires careful engineering and testing throughout the design and construction phase. The testing should cover strength, durability, permability, and other factors, including environmental.[9]

An innovative tile product sold by Granite & Marble World Trade (GMWT) uses water-jet cutting technology to help create inlay patterns and textured surfaces on stone tiles. Creative Edge of Fairfield, IA, GMWT's joint venturer, makes the tile and is presently cutting a 15-foot by 30-foot granite mural of the Chicago skyline for GMWT. Inlay work has traditionally been done entirely by hand.

Outlook

Projected demand for dimension granite totaled 1.7 million tons for 1995 and 2.5 million tons for the year 2000. Demand for dimension marble totaled 750,000 tons for 1995 and 1.1 million tons for the year 2000. Demand for dimension limestone totaled 350,000 tons for 1995 and 390,000 tons for the year 2000, while demand for slate should be 55,000 tons in 1995 and 57,000 tons in the year 2000. This relatively slow rate reflects a major drop in the market for building stone in 1989-91 and a welcomed major recovery later in the 1990's. Certain segments will continue to grow rapidly, such as uses in kitchens and bathrooms. The supply will be adequate and is likely to shift in favor of domestic producers.

OTHER SOURCES OF INFORMATION

Bureau of Mines Publication

Dimension Stone. Ch. in Mineral Commodity Summaries, annual.
Dimension Stone. Ch. in Minerals Yearbook, annual.
Dimension Stone. Reported annually in Mineral Industry Surveys.
Directory of Principal Dimension Stone Producers in the United States.
Leading Country Activity.
Market Activity.

Other Sources

Dimensional Stone.
Industrial Minerals (United Kingdom).
Stone Industries (United Kingdom).
Stone World.

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[1] Napoli, S. International Trends in the Stone Industry. Dimensional Stone, v. 8, No. 9, Sept. 1992, pp. 36-40.

[2] Robinson, M. Forming a Stone Industry Down Under. Stone World, v. 9, No. 9, Sept. 1992, pp. 73-87.

[3] Taylor, H., Jr. Japan Wants Granite. Stone World, v. 9, No. 6, June 1992, pp. 38-44.

[4] Lombardero, M., and M. Regueiro. Spanish Natural Stone-Cladding the World. Ind. Miner. (London), No. 300, Sept. 1992, pp. 81-97.

[5] Harries-Rees, K. Industrial Minerals of the UK-Keeping Afloat. Ind. Miner. (London), No. 293, Feb. 1992, pp. 21-30.

[6] Marble Institute of America. Dimension Stones of the World, Volume I. Marble Inst. of Am., Farmington, MI, 1992, 680 pp.

[7] Hannibal, J. and Park, L. A Guide to Selected Sources of Information on Stone. Stone World, v. 9, No. 11, Nov. 1992, pp. 45-86.

[8] Mathews, J. The Right Stone for the Right Job. Dimensional Stone, v. 8, No. 9, Sept. 1992, pp. 32-34.

[9] Stecich, J., I. Chin, and F. Heidbrink. Testing for Thin Stone Veneers on Buildings. Dimensional Stone, v. 8, No. 11, Nov. 1992, pp. 28-35.

TABLE 1
SALIENT U.S. DIMENSION STONE STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
Sold or used by producers:					
Quantity 2/	1,120 e/	1,160	1,140 r/	1,280 r/	1,190
Value 2/	$232,000 e/	$211,000	$198,000 r/	$226,000 r/	$218,000
Exports (value)	$54,000	$64,900	$54,900	$52,700 r/	$53,000
Imports for consumption (value)	$586,000	$475,000	$404,000	$398,000	$440,000

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits.

2/ Includes Puerto Rico.

TABLE 2
U.S. IMPORT DUTIES ON DIMENSION STONE

Tariff item	HTS. No.	Most favored nation (MFN)	Non-MFN
		Jan. 1, 1995	Jan. 1, 1995
Slate: Rough blocks or slabs	2514.00.0000	3% ad valorem	25% ad valorem.
Rough blocks or slabs of marble, travertine, and other calcareous monumental or building stone:	2515.00.0000		
Marble and travertine:			
Crude or roughly trimmed	2515.11.0000	$2.77 per cubic meter	$22.95 per cubic meter.
Marble, merely cut	2515.12.0010	1.7% ad valorem	13% ad valorem.
Travertine, merely cut	2515.12.0020	5.4% ad valorem	50% ad valorem.
Other calcareous stone alabaster	2515.20.0000	5.4% ad valorem	50% ad valorem.
Rough blocks or slabs of granite, porphyry, basalt, sandstone, and other monumental or building stone:	2516.00.0000		
Granite:			
Crude or roughly trimmed	2516.11.0000	Free	$8.83 per cubic meter.
Merely cut	2516.12.0000	3.9% ad valorem	60% ad valorem.
Sandstone:			
Crude or roughly trimmed	2516.21.0000	Free	$5.30 per cubic meter.
Merel ycut	2516.22.0000	5.4% ad valorem	50% ad valorem.
Other monumental or building stone	2516.90.0000	5.4% ad valorem	50% ad valorem.
Setts, curbstones, and flagstones	6801.00.0000	3.9% ad valorem	60% ad valorem.
Worked monumental or building stone	6802.00.0000		
Tiles and cubes under 7cm square, granules	6802.10.0000	6.5% ad valorem	40% ad valorem.
Other stone and articles with a flat or even surface:			
Marble, travertine and alabaster:	6802.21.0000		
Travertine:	6802.21.1000	5.6% ad valorem	50% ad valorem.
Other:	6802.21.5000	2.1% ad valorem	13% ad valorem.
Other calcareous stone	6802.22.0000	5.8% ad valorem	50% ad valorem.
Granite	6802.23.0000	4.1% ad valorem	60% ad valorem.
Other stone	6802.29.0000	7.2% ad valorem	30% ad valorem.
Other:			
Marble, travertine, and alabaster:	6802.91.0000		
Marble:			
Slabs:	6802.91.0500	2.7% ad valorem	15% ad valorem.
Other:	6802.91.1500	5.8% ad valorem	50% ad valorem.
Travertine:			
Articles of subheading 6802.21.1000 that have been dressed or polished, but not further worked	6802.91.2000	5.6% ad valorem	50% ad valorem.
Other	6802.91.2500	5% ad valorem	40% ad valorem.
Alabaster	6802.91.3000	5.2% ad valorem	50% ad valorem.
Other calcareous stone	6802.92.0000	5.8% ad valorem	50% ad valorem.
Granite	6802.93.0000	4.1% ad valorem	60% ad valorem.
Other stone	6802.99.0000	6.5% ad valorem	40% ad valorem.
Worked slate and articles:	6803.00.0000		
Roofing slate	6803.00.0010	5.9% ad valorem	25% ad valorem.
Other	6803.00.0050	3% ad valorem	25% ad valorem.

TABLE 3
DIMENSION STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, 1/ BY STATE 2/ 3/

State	1992 r/		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
California	27,700	4,940	22,300	$5,640
Colorado	5,008	1,268	7,030	$1,270
Georgia 3/	152,000	17,300	188,000	17,800
Indiana 3/	163,000	23,700	173,000	25,800
Kansas 3/	23,900	2,650	23,700	1,730
Maryland	15,700	1,620	20,800	1,700
Massachusetts	94,100	6,330	57,300	9,600
Minnesota	38,500	8,020	W	W
New Hampshire	24,300	4,350	22,500	3,820
New York	41,600	9,470	32,100	8,860
North Carolina 3/	30,100	10,800	41,200	14,500
Ohio	29,500	1,300	W	W
Oklahoma 3/	3,130	545	3,980	1,250
Pennsylvania	50,100	11,800	57,200	12,100
South Dakota	31,800	6,290	W	W
Utah	21,800	2,400	W	W
Vermont	102,000	33,400	87,100	28,700
Wisconsin	78,600	9,650	118,000	14,900
Other 4/	209,000	43,900	337,000	70,100
Total	1,140,000	198,000	1,190,000	218,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Includes Puerto Rico.

2/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

3/Totals only include Georgia granite, Indiana limestone, Kansas limestone, North Carolina granite and Oklahoma granite and limestone (1994); other stone included with "Other."

4/ Includes data for Alabama, Arizona, Arkansas, Connecticut, Idaho, Illinois (1994), Iowa, Maine, Michigan, Missouri, Montana, New Mexico, South Carolina, Tennessee, Texas, Washington and West Virginia.

TABLE 4
DIMENSION GRANITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

State	1992 r/		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Georgia	152,000	17,300	188,000	17,800
Massachusetts	94,100	6,330	57,300	9,600
New Hampshire	24,300	4,350	22,500	3,820
North Carolina	28,000	10,200	37,800	13,300
Oklahoma	3,130	545	2,280	1,110
Pennsylvania	11,900	3,390	10,600	2,900
Vermont	80,600	16,800	55,100	11,500
Wisconsin	3,040	2,870	3,320	2,910
Other 2/	128,000	23,300	122,000	27,700
Total	525,000	85,000	499,000	90,700

r/ Revised.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes California, Colorado, Connecticut, Maine, Minnesota, Missouri, New York, South Carolina, South Dakota, Texas, and Virginia.

TABLE 5
DIMENSION LIMESTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

State	1992 Quantity (metric tons)	1992 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Indiana	163,000	$23,700	173,000	$25,800
Kansas	23,900	2,650	23,700	1,730
Minnesota	18,200	8,020	W	W
Oklahoma	--	--	1,700	146
Wisconsin	75,600	6,790	114,000	12,000
Other 2/	94,600	8,990	52,900	18,800
Total	375,000	50,100	366,000	58,500

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes Alabama, Arkansas, California, Iowa, New Mexico, New York (1992), Ohio, Texas, and Utah.

TABLE 6
DIMENSION SANDSTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

State	1992 Quantity (metric tons)	1992 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
New York	19,500	$3,910	21,800	$6,200
Pennsylvania	27,700	3,780	25,300	3,560
Other 2/	93,200	5,550	125,000	5,850
Total	140,000	13,200	172,000	15,600

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes Alabama, Arizona, Arkansas, California, Colorado, Indiana (1992), Kansas, Michigan, North Carolina, Ohio, Oklahoma, and Utah.

TABLE 7
DIMENSION STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, 1/ BY USE 2/

Use	1992 e/ Quantity (metric tons)	1992 e/ Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Rough stone:				
Rough blocks for building and construction	223,000	$27,700	339,000	$37,300
Irregular-shaped stone	95,300	9,760	134,000	8,060
Monumental	201,000	20,600	189,000	23,100
Other 3/	W	W	40,300	8,030
Dressed stone:				
Ashlars and partially squared pieces	199,000	31,800	145,000	34,200
Slabs and blocks for building and construction	53,900	26,100	32,700	17,000
Monumental	42,500	22,800	31,900	21,800
Curbing	143,000	19,900	97,200	18,600
Flagging	94,400	4,170	80,300	9,110
Flagging (slate)	5,710	870	7,200	1,650
Roofing slate	11,200	9,480	14,600	12,100
Structural and sanitary	3,140	2,780	4,860	4,290
Flooring slate	2,470	1,940	4,750	2,850
Other 3/	63,300	20,600	70,800	20,000
Total	1,140,000	198,000	1,190,000	218,000

e/ Estimated. W Withheld to avoid disclosing company proprietary data, included in "Dressed stone: Other."

1/ Includes Puerto Rico.

2/ Data rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes uses not specified.

TABLE 8
DIMENSION GRANITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

Use	1992 e/ Quantity (metric tons)	1992 e/ Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Rough stone:				
Rough blocks for building and construction	75,400	$13,100	131,000	19,500
Irregular-shaped stone 2/	3,520	849	16,400	3,500
Monumental	197,000	18,900	185,000	22,000
Dressed stone:				
Ashlars and partially squared pieces	57,200	13,300	22,700	7,550
Slabs and blocks for building and construction	11,700	6,060	2,310	917
Monumental	37,800	13,400	26,300	12,600
Curbing	134,000	19,200	97,100	18,500
Other 3/	7,590	335	18,000	6,120
Total	525,000	85,000	499,000	90,700

e/ Estimated.

1/ Data rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes rubble and a minor amount of uses not specified.

3/ Includes stone used for flagging, paving block, and unspecified uses for dressed stone.

TABLE 9
DIMENSION LIMESTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

Use	1992 e/ Quantity (metric tons)	1992 e/ Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Rough stone:				
Rough blocks for building and construction	113,000	$8,830	154,000	$12,700
Irregular-shaped stone 2/	50,300	3,810	27,900	1,830
Dressed stone:				
Ashlars and partially squared pieces	67,000	10,000	86,700	22,000
Slabs and blocks for building and construction	28,900	9,260	21,600	9,010
Flagging	62,000	1,060	23,300	2,880
Other 3/	54,400	17,200	52,400	10,100
Total	375,000	50,100	366,000	58,500

e/ Estimated.

1/ Data rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes uses not specified.

3/ Includes dressed monumental, curbing, and unspecified uses for dressed stone.

TABLE 10
DIMENSION MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES 1/, BY USE 2/

Use	1992 e/ Quantity (metric tons)	1992 e/ Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Rough stone:				
Rough blocks for building and construction	13,800	$6,380	17,300	$2,940
Other 3/	3,230	1,490	5,710	1,250
Dressed stone:				
Ashlars and partially squared pieces	W	W	3,560	683
Slabs and blocks for building and construction	7,140	9,510	4,760	6,620
Other 4/	5,670	9,110	4,950	9,250
Total	29,800	26,500	36,300	20,700

e/ Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Puerto Rico.

2/ Data rounded by the U. S. Bureau of Mines to three significant digits; May not add to totals shown.

3/ Includes rubble, irregular shaped stone, moumental stone, and unspecified uses.

4/ Includes stone used for monumental purposes, a small amount of flagging, and unspecified.

TABLE 11
DIMENSION SANDSTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

Use	1992 e/		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	18,800	$865	19,800	$1,080
Irregular-shaped stone 2/	28,300	3,590	78,000	3,580
Other 3/	--	--	W	W
Dressed stone:				
Ashlars and partially squared pieces	61,200	6,390	19,700	2,280
Slabs and blocks for building and construction	2,880	450	4,080	466
Flagging	17,600	1,210	44,000	4,850
Other 4/	11,700	728	6,180	3,350
Total	140,000	13,200	172,000	15,600

e/ Estimated. W Withheld to avoid disclosing company proprietary data.

1/ Data rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes rubble.

3/ Includes uses not specified.

4/ Includes dressed monumental, curbing, and unspecfied uses for dressed stone.

TABLE 12
DIMENSION SLATE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

Use	1992 e/		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Flagging	5,710	$859	7,230	$1,650
Roofing	11,200	9,360	14,600	12,100
Structural and sanitary purposes	3,140	2,750	4,880	4,290
Flooring	2,470	1,920	4,770	2,850
Other 2/	3,490	1,840	3,740	2,270
Total	26,000	16,700	35,200	23,200

e/ Estimated.

1/ Data rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes a minor amount of slate used for billard tabletops, blackborard, school slates, and unspecified uses.

TABLE 13
U.S. EXPORTS OF DIMENSION STONE, BY TYPE 1/

(Thousand metric tons and thousand dollars)

	1993		1994		Major destination
Type	Quantity	Value	Quantity	Value	in 1994, (percent 2/)
Marble, travertine, alabaster worked	35 r/	$2,560	18	$3,130	Canada, 24%
Marble, travertine - crude or roughly trimmed	3	936	2	531	Canada, 52%
Marble, travertine - merely cut, by sawing or otherwise	4 r/	1,100	22	2,540	Mexico, 15%
Granite, crude or roughly trimmed	61	13,800	97	22,000	Italy, 33%
Granite, merely cut by sawing or otherwise	72 r/	17,800	65	14,100	Taiwan, 26%
Granite, dressed, worked	9	5,180	8	7,530	Hong Kong, 12%
Sandstone, crude or roughly trimmed	1	286	1	207	Canada, 85%
Sandstone, merely cut, by sawing or otherwise	6	1,230	6	1,130	Canada, 93%
Slate, worked and articles of slate	NA	11,100	NA	6,090	Belize, 25%
Slate, whether or not roughly trimmed or merely cut	NA	740	NA	760	Canada, 54%
Other calcareous monumental or building stone; alabaster	4	942	3	1,240	Canada, 48%
Other monumental or building stone	14 r/	2,220	8	1,270	Canada, 72%
Total	XX	52,700	XX	53,000	

r/ Revised. NA Not available. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ By value.

Source : Bureau of the Census.

TABLE 14
U.S IMPORTS FOR CONSUMPTION OF DIMENSION GRANITE, BY COUNTRY 1/

(Thousand dollars)

			Dressed worked granite								
		Dressed		Cut to size							
Country	Rough granite 2/	granite articles	Not cut to size	Max 1.5 cm	1.5-10 cm	All 3/ Min 10 cm	Monumental Min 10 cm	Building Min 10 cm	Other	Total Worked	Total Dressed
1993:											
Argentina	$97	$149	$280	$50	$195	--	--	$34	$178	$737	$886
Brazil	332	1,370	2,620	988	5,380	$19	$19	21	1,680	10,700	12,100
Canada	3,260	1,840	2,000	662	3,260	1,470	835	548	2,880	11,700	13,500
China	113	340	196	353	392	170	47	10	1,160	2,330	2,670
Finland	115	37	74	--	92	--	--	--	5	171	208
India	750	1,640	1,490	2,480	3,600	3,310	1,060	594	2,650	15,200	16,800
Italy	592	4,030	7,750	2,960	11,300	1,060	25	503	15,900	39,500	43,600
Japan	41	148	--	--	14	--	--	--	590	604	752
Mexico	106	54	--	5	96	--	--	--	117	218	272
Norway	215	--	--	--	28	26	12	--	48	114	114
Portugal	248	209	35	8	20	--	--	--	499	562	771
Saudi Arabia	89	30	425	46	117	--	--	--	43	630	660
South Africa, Republic of	915	393	84	71	88	10	--	10	151	414	807
Spain	228	685	694	641	1,930	--	--	25	1,660	4,950	5,630
Other	583	228	490	404	662	--	10	15	1,150	2,730	2,960
Total	7,690	11,200	16,100	8,670	27,200	6,060	2,010	1,760	28,700	90,500	102,000
1994:											
Argentina	26	225	51	22	141	NA	--	36	51	301	526
Brazil	294	1,380	5,770	1,230	6,530	NA	287	160	3,810	17,800	19,200
Canada	3,460	1,590	1,370	63	3,400	NA	2,220	1,070	3,690	11,800	13,400
China	169	543	268	825	321	NA	55	226	1,500	3,190	3,740
Finland	12	28	24	--	21	NA	4	--	22	71	99
India	1,450	2,140	2,090	2,920	5,760	NA	3,350	1,440	4,600	20,100	22,300
Italy	729	2,970	11,000	2,560	13,800	NA	71	1,920	19,400	48,900	51,800
Japan	55	44	--	4	21	NA	--	--	102	127	171
Mexico	52	22	20	59	502	NA	--	26	158	765	787
Norway	156	--	10	45	19	NA	42	--	2	117	117
Portugal	799	--	35	--	54	NA	--	44	18	151	151
Saudi Arabia	129	2	352	29	82	NA	--	--	1	464	466
South Africa, Republic of	839	264	116	151	113	NA	85	169	250	885	1,150
Spain	70	485	1,090	659	3,410	NA	3	175	1,090	6,420	6,910
Other	577	289	429	552	499	NA	--	4	748	2,230	2,520
Total	8,810	9,980	22,700	9,120	34,700	NA	6,120	5,270	35,500	113,000	123,000

NA Not available.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes crude or roughly trimmed, and merely cut by sawing or otherwise.

3/ In 1993 all granite with a minimum thickness of 10 cm was divided into monumental and building.

Sources: Bureau of the Census.

TABLE 15
U.S IMPORTS FOR CONSUMPTION OF MAJOR CATEGORIES OF DIMENSION MARBLE AND OTHER CALCAREOUS STONE, BY COUNTRY 1/

Country	Dressed marble slabs		Dressed marble - other		Dressed marble and other calcareous stone 2/		Rough marble 3/	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
China	922	$749	839	$1,030	1,930	$1,520	99	$74
France	62	97	307	421	23,400	11,500	25	29
Greece	12,200	7,650	3,690	4,600	3,550	2,970	273	92
India	237	228	564	659	258	152	168	58
Italy	26,000	24,500	34,800	33,800	25,700	24,600	707	938
Mexico	336	334	1,090	1,370	9,790	8,440	87	138
Portugal	1,280	1,360	1,040	1,280	5,440	3,980	22	9
Spain	2,590	2,260	3,720	4,370	24,900	21,200	166	289
Other	9,950	9,100	8,360	12,800	11,900	7,330	247	233
Total	53,600	46,300	54,400	60,300	107,000	81,800	1,800	1,860
1994:								
China	1,140	696	2,670	2,060	2,000	1,720	114	89
France	125	150	211	414	9,060	10,200	4	4
Greece	4,730	5,200	3,980	4,290	4,140	4,640	118	83
India	616	610	925	934	411	282	2	4
Italy	25,200	24,800	36,900	34,400	32,400	27,000	779	966
Mexico	1,340	1,290	1,590	1,290	6,620	6,610	52	35
Portugal	940	981	1,260	1,090	6,560	4,440	24	24
Spain	3,270	2,470	5,870	5,630	27,900	23,400	20	8
Other	11,100	9,500	9,610	12,800	12,700	7,250	242	351
Total	48,500	45,600	63,100	62,900	102,000	85,500	1,360	1,560

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ HTS No. 6802.92.0000: The material from Italy is almost all marble; from France, is both limestone and marble; from Spain is almost all marble; and from Mexico, is both limestone and marble.

3/ Marble-merely cut by sawing or otherwise.

Source: Bureau of the Census as modified by the U.S. Bureau of Mines.

TABLE 16
U.S. IMPORTS FOR CONSUMPTION OF DIMENSION STONE, BY TYPE 1/

Type		1993		1994		Major source for 1994, (percent 2/)
		Quantity	Value (thousands)	Quantity	Value (thousands)	
Calcareous stone-other 3/	metric tons	18,700	$3,290	72,600	$6,590	Spain,27%
Marble, travertine alabaster and other	do.	3,370	3,470	3,540	3,170	Italy,47%
Sandstone, merely cut, by sawing or otherwise	do.	102	60	151	148	Canada,42%
Slate, roofing	million square feet	4.0	1,840	8	3,290	Spain,33%
Slate, whether or not roughly trimmed or merely cut	do.	5,940	2,570	2,790	1,630	Italy,83%
Slate, worked and articles of slate, and other	do.	NA	20,800	NA	22,700	Italy,48%
Stone, worked monumental or building stone-other	metric tons	44,100	49,200	52,100	55,600	Italy,30%
Travertine, monumental or building stone and articles thereof	do.	6,850	3,930	6,650	3,530	Italy,90%
Travertine, worked monumental or building stone	do.	10,100	8,350	13,100	10,600	Italy,83%
Other monumental or building stone	do.	14,900	3,500	14,700	3,090	South Africa, Rep. of, 62%
Other stone-monumental or building stone-articles thereof	do.	2,490	1,190	3,410	1,780	Mexico,40%

NA Not available.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ By value.

3/ HTS No. 6802.22.0000.

Source: Bureau of the Census.

STRONTIUM

By Joyce A. Ober

Strontium occurs commonly in nature, averaging 0.034% of all igneous rock; however, only two minerals, celestite (strontium sulfate) and strontianite (strontium carbonate), contain strontium in sufficient quantities to make its recovery practical. Of the two, celestite occurs much more frequently in deposits of sufficient size to make development of mining facilities currently attractive. Strontianite would be the more useful of the two common minerals because strontium is used most commonly in the carbonate form, but few deposits have been discovered that are suitable for development. There is only one strontianite mine in the world.

Chemical Products Corp. (CPC) of Cartersville, GA, was the only U.S. producer of strontium compounds from celestite. CPC produced strontium carbonate from imported ore because there were no active celestite mines in the United States.

Legislation and Government Programs

Government stockpiling of celestite began in 1942 to provide a secure supply of celestite for the production of strontium compounds required for defense applications during World War II. Celestite purchase specifications issued in 1960 for the U.S. National Defense Stockpile established quality requirements at greater than 95% strontium sulfate content with less than 1.5% calcium sulfate and less than 2% barium sulfate.

In 1963, the stockpile was determined to be unnecessary, and the General Services Administration began selling stockpile material. All the stockpile-grade celestite was sold by 1973, with the remaining material grading less than 91% strontium sulfate and more than 4% calcium sulfate and some with more than 10% barium sulfate.

About 3,300 metric tons of celestite was offered for sale in 1994, the first time celestite from the stockpile had been offered since 1980; no bids were accepted. The stockpile currently contains approximately 12,000 tons of celestite. The low quality of the material remaining in the stockpile will make it difficult to dispose of; the stockpile reports issued by the Defense National Stockpile Center—the agency now responsible for managing stockpile sales—list the celestite as valueless.

Production

The sole U.S. strontium carbonate producer voluntarily provided domestic production and sales data to the U.S. Bureau of Mines. Production and stock data, however, were withheld from publication to avoid disclosing company proprietary data. *(See table 1.)*

Although there have been no active celestite mines in the United States since 1959, celestite deposits have been identified nationwide. During World War II, domestic mining of celestite resources was conducted in Texas and California. U.S. celestite mines had at that time been inactive since World War I, and strontium minerals were imported to satisfy domestic demand.

CPC is the only domestic company that produces strontium carbonate from celestite; the company also produces strontium nitrate. All the celestite CPC used in 1994 was imported from Mexico. CPC utilizes the black ash method of strontium carbonate production at its facility.

The black ash method and the soda ash method are the two most common recovery techniques. The black ash method, known alternatively as the calcining method, produces chemical-grade strontium carbonate, which contains at least 98% strontium carbonate. The soda ash or direct conversion method produces technical-grade strontium carbonate, containing at least 97% strontium carbonate.

The first step in the black ash process involves mixing the crushed and screened celestite with powdered coal. The mixture is then heated to about 1,100° C, expelling oxygen in the form of carbon dioxide from the insoluble strontium sulfate to form water-soluble strontium sulfide.

Strontium sulfide is dissolved in water and the resulting solution filtered. Carbon dioxide is then passed through the solution or soda ash is added, forming and precipitating strontium carbonate from solution. The precipitated strontium carbonate is then filtered, dried, ground, and packaged. The byproduct sulfur from the process is recovered as elemental sulfur or as other byproduct sulfur compounds.

In the soda ash method, ground celestite is washed and most of the water removed. The thickened mixture is combined with soda ash and treated with steam for 1 to 3 hours. During this time, celestite and soda ash react to form strontium carbonate and sodium sulfate. Sodium sulfate is water soluble, making it possible to separate the insoluble strontium carbonate by centrifuging. The black ash method is the preferred means of strontium carbonate production due to the higher grade product, and most new production facilities employ black ash technology.

Several U.S. companies produced strontium metal and compounds from strontium carbonate. Calstron Corp. of Memphis, TN, produced strontium metal, Mallinkrodt Inc. of St. Louis, MO, produced strontium chloride, and Mineral Pigments Corp. of Beltsville, MD, produced strontium chromate. A few other companies produced downstream strontium compounds, but on a very small scale.

Consumption

The U.S. Bureau of Mines estimated the distribution of strontium compounds by end use. Of the 11 operations to which a survey request was sent, all responded. The information collected from this survey and the information provided by the U.S. Bureau of the Census on strontium trade were the basis for the end-use estimates shown in table 2.

In 1994, approximately 80% of all strontium was consumed in ceramics and glass manufacture, primarily in television faceplate glass and ceramic ferrite magnets, and in smaller amounts in other ceramic and glass applications. Over the past 20 years, production of faceplate glass for color television picture tubes has become the major consumer of strontium.

All color televisions and other devices containing color cathode-ray tubes sold in the United States are required by law to contain strontium in the faceplate glass of the picture tube to block X-ray emissions. Major manufacturers of television picture tube glass incorporate about 8%, by weight, strontium oxide in their glass faceplate material. Added to the glass melt in the form of strontium carbonate, strontium carbonate is converted to strontium oxide. In addition to blocking X-rays, the strontium improves the appearance of the glass, increasing the brilliance and improving the quality of the picture.

Permanent ceramic magnets were another large end use for strontium compounds, in the form of strontium ferrite. These magnets are used extensively in small direct current (dc) motors used in automobile windshield-wipers, loudspeakers, other electronic equipment, toys, and magnetically attached decorative items.

Strontium ferrite magnets have high coercive force, high thermal and electrical resistivity, and are chemically inert. They retain their magnetism well, are not adversely affected by electrical currents or high temperatures, do not react with most chemical solvents, resist demagnetization and are low density.

One of the most consistent and continuing applications for strontium has been in pyrotechnic devices. Strontium burns with a brilliant red flame, and no other material has been found to be better in this application.

The strontium compound used most frequently in pyrotechnic devices was strontium nitrate. Strontium carbonate, strontium oxalate, strontium sulfate, and strontium chlorate can be used in pyrotechnic applications, but strontium nitrate is used in significantly larger quantities than any of these.

Pyrotechnic devices were used in military and nonmilitary applications. Military pyrotechnic applications that contained strontium included tracer ammunition, military flares, and marine distress signals. Nonmilitary applications included warning devices and fireworks.

Strontium is used to remove lead impurities during the electrolytic production of zinc. The addition of strontium carbonate in sulfuric acid to the electrolyte reduces the lead content of the electrolyte and of the zinc that is deposited on the cathode.

Strontium chromate is an additive to corrosion resistant paint. It is an effective coating for aluminum, most notably on aircraft fuselages and ships. These paints are used to some degree on aluminum packaging to prevent package corrosion.

Strontium metal is a very limited part of total strontium consumption. Small amounts of strontium are added to molten aluminum to improve the castability of the metal, making it more suitable for casting items that have been traditionally made from steel. The addition of strontium to the melt improves the machinability of the casting. The use of cast aluminum parts is currently gaining popularity in the automotive industry because the weight reduction of the automobile from using cast aluminum parts instead of steel improves energy efficiency.

Other end uses consume only small amounts of strontium and strontium compounds. As mentioned previously, the presence of strontium in glass applications improves the brilliance of the glass. It also improves the quality of certain ceramic glazes as well as eliminating the toxicity that may be present in glazes containing lead or barium. One high-tech strontium ceramic is strontium titanate, which is sometimes used as substrate material for semiconductors and also in some optical and piezoelectric applications.

Strontium chloride was used in toothpaste for temperature-sensitive teeth. For this application, impurities must be strictly controlled, with limits for some of them in the parts per million range.

Strontium phosphate was used in the manufacture of fluorescent lights, and the entire range of strontium chemicals was used in analytical chemistry laboratories. *(See table 2.)*

Prices

The average customs value for celestite imported from Mexico was about $68 per ton, 7% lower than the average value in 1993. Mexico was the source of nearly 100% of 1994 celestite imports.

The average unit customs value of imported strontium carbonate was $0.60 per kilogram and the average value for strontium nitrate was $0.97 per kilogram; the unit value for strontium carbonate was virtually the same as in 1993, and the strontium nitrate value was 15% higher.

Foreign Trade

According to reports from the U.S. Bureau of the Census, exports of strontium compounds increased more than 300% from the levels reported in 1993. Imports of celestite—all from Mexico—increased 35%.

Mexico was once again the most important source for imported strontium compounds; Germany was second. Imports of strontium carbonate in 1994 were 34% higher than those in 1993, with imports from Mexico comprising 85% of total carbonate imports. Imports of strontium nitrate were 94% lower than in 1993. *(See tables 3, 4, and 5.)*

World Review

In almost all instances, celestite deposits occur in remote, undeveloped locations far from population centers in areas where inexpensive labor is available for mining. Huge deposits of high-grade celestite have been discovered throughout the world. Strontium commonly occurs along with barium and calcium, two elements with chemical properties very similar to strontium, thus making separation difficult. Because removing many impurities from celestite is difficult and energy intensive, current strontium chemical producers require material to contain at least 90% strontium sulfate. Most of the currently operating celestite facilities can produce sufficient supplies with only minimal processing necessary to achieve acceptable specifications. Hand sorting and some washing are all that are necessary at many strontium mines; a few operations use gravity separation, froth flotation, or other methods to beneficiate ore.

Detailed information on most world resources is not readily available. Many of the large deposits are in remote, sparsely inhabited areas, and very little formal exploration has been done. Other deposits may be well identified but are located in countries from which specific mineral information is not easily obtained.

Leading celestite producers are Mexico, Turkey, Iran, and Spain, in decreasing order of importance. Significant quantities of celestite are produced in China and the former U.S.S.R.; however, not enough information is available to make any estimate of location, number, or size of mines. Celestite is produced in smaller quantities in Algeria, Argentina, and Pakistan.

Until World War II, practically all celestite produced worldwide was from the United Kingdom; for several years following the end of the war the United Kingdom maintained its importance. Depleted reserves, encroaching civilization, and the discovery of vast deposits in other countries, resulted in the cessation of production in the United Kingdom. Any reported U.K. celestite production since 1992, was due to the reprocessing of mine tailings from the exhausted mine. *(See table 6.)*

Strontium compounds and/or metal production facilities are found in Canada, China, Germany, Japan, the Republic of Korea, Mexico, the United States, and the former U.S.S.R.

Outlook

Sales of televisions in the United States were at record high levels in 1994. In fact, sales and production were so high that faceplate glass was in short supply, and imports of glass were increasing. Because U.S. TV glass producers are operating at capacity, domestic consumption of strontium carbonate for this end use will remain at current levels until additional capacity is installed. However, worldwide demand for strontium carbonate will increase to meet the demand for U.S. glass imports.

Growth in television sales is expected to continue and larger screens are expected to increase in popularity, and so demand for strontium carbonate for television application should expand. Other markets will probably continue at their current, slower rate.

Development of a technology to produce an affordable flat television display could severely reduce the demand for strontium carbonate, but this is not expected in the near future. Although a high-quality, large, flat screen is not yet available, small models are, and research continued to improve the technology. The question remains whether a new display system can be developed that will be economically attractive to the general public. Initial devices are expected to find application in military hardware and other sophisticated medical and scientific instrumentation. Flat screen display systems may eventually replace cathode-ray tubes, and, at that point, strontium producers may experience a serious setback.

OTHER SOURCES OF INFORMATION

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TABLE 1
SALIENT STRONTIUM STATISTICS 1/

(Metric tons of contained strontium unless otherwise noted 2/)

	1990	1991	1992	1993	1994
United States:					
Production, strontium minerals	--	--	--	--	--
Imports for consumption: 3/					
Strontium minerals	21,500	14,600	19,700	11,600	16,000
Strontium compounds	11,800	9,550	13,000	15,300	20,000
Exports (compounds) 3/	700	1,080	650	260	110
Shipments from Government stockpile excesses	--	--	--	--	--
Price, average value of mineral imports at port of exportation, dollars per ton	86	77	68	73	68
World production 4/ (celestite)	240,000	199,000	139,000	156,000 r	150,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ The strontium content of celestite is 43.88%, which was used to convert units to celestite.

3/ Source: Bureau of the Census.

4/ Excludes China and the former U.S.S.R.

TABLE 2
U.S. ESTIMATED DISTRIBUTION OF PRIMARY STRONTIUM COMPOUNDS, BY END USE

(Percent)

End use	1993	1994
Electrolytic production of zinc	2	2
Ferrite ceramic magnets	13	11
Pigments and fillers	5	6
Pyrotechnics and signals	11	9
Television picture tubes	66	69
Other	3	3
Total	100	100

TABLE 3
U.S. EXPORTS OF STRONTIUM COMPOUNDS, BY COUNTRY 1/

	1993		1994	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Strontium carbonate precipitated:				
Brazil	--	--	(3/)	$6
Canada	365	$302	381	354
Germany	1	3	--	--
India	--	--	(3/)	3
Japan	--	--	14	13
Malaysia	--	--	1,220	402
Mexico	--	--	1	4
United Kingdom	9	69	2	16
Total	375 r/	374	1,620	798
Strontium oxide, hydroxide, and peroxide:				
Argentina	--	--	19	30
Belgium	36	37	177	18
Canada	--	--	40	26
Germany	--	--	1	8
Iceland	(3/)	4	--	--
Japan	1	9	--	--
Korea, Republic of	--	--	1	8
Norway	--	--	1	16
Thailand	16	12	--	--
Turkey	1	15	--	--
United Kingdom	--	--	4	4
Total	54	77	243	110

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Customs value.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF STRONTIUM MINERALS, 1/ 2/ 3/ BY COUNTRY

Country	1993		1994	
	Quantity (metric tons)	Value 3/ (thousands)	Quantity (metric tons)	Value 3/ (thousands)
Mexico	26,400	$1,920	35,500	$2,420
Other	(4/)	12 r/	(4/)	6
Total	26,400	1,930	35,500	2,420

r/ Revised.
1/ Celestite (strontium sulfate).
2/ Customs value.
3/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
4/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF STRONTIUM COMPOUNDS, BY COUNTRY 1/

	1993		1994	
	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Strontium carbonate:				
China	176	$84	101	$44
Germany	3,110	1,960	4,880	2,920
Italy	2	6	6	13
Japan	(3/)	7	(3/)	8
Mexico	21,500	12,500	28,100	16,900
Total	24,800	14,500	33,100	19,900
Strontium nitrate:				
China	4	3	4	5
Cote d' Ivoire	--	--	1	13
Germany	--	--	(3/)	3
Japan	(3/)	5	--	--
Mexico	1,530	1,280	84	65
Total	1,530	1,290	89	86

1/ Previously published and 1994 data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Customs value.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 6
STRONTIUM MINERALS: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Algeria (celestite) e/	5,400	5,400	5,400	5,400	5,400
Argentina	3,110	1,200	1,200 e/	-- r/	--
Iran (celestite) 4/	34,100	28,500	13,100	20,000 e/	20,000
Mexico (celestite)	66,300	62,200	61,100	71,900 r/	70,000
Pakistan	1,800	1,470	1,450	1,680 r/	1,500
Spain e/ 5/	31,000	28,000	18,000	12,000	12,000
Turkey (celestite)	73,800	70,000	37,900	43,700 r/	40,000
United Kingdom e/	24,700 6/	2,000	1,000	1,000	1,000
Total	240,000	199,000	139,000	156,000 r/	150,000

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through May 5, 1995.

3/ In addition to the countries listed, China and Poland produce strontium minerals, but output is not reported quantitatively, and available information is inadequate to make reliable estimates of output levels.

4/ Data are for year beginning Mar. 21 of that stated.

5/ Sr2O4 content.

6/ Reported figure.

SULFUR

By Joyce A. Ober

Sulfur, through its major derivative sulfuric acid, ranks as one of the more important elements utilized by humanity as an industrial raw material. It is of prime importance to every sector of the world's industrial and fertilizer complexes. Sulfuric acid production is the major end use for sulfur and sulfuric acid consumption has been regarded as one of the best indexes of a nation's industrial development. More sulfuric acid is produced in the United States every year than any other chemical; nearly 90 million tons were produced in 1994, 13% more than the previous year.[1]

Domestic production of sulfur increased in 1994 for the second consecutive year and consumption increased after 4 years of decline. The United States maintained its position as the leading producer and consumer of sulfur and sulfuric acid in the world. The quantity of sulfur recovered during the refining of petroleum and the processing of natural gas continued its upward trend established in 1938, the year the U.S. Bureau of Mines (USBM) started publishing data on the production of this type of sulfur. The production of sulfur through the Frasch process was significantly higher in 1994 although direct comparisons to 1993 data are not possible because listed production data reflected only 10 months of Frasch data to conform with proprietary data requirements. Frasch production data for 1994 were estimated based on reports published by the two remaining Frasch producers and the State of Texas. Total production of sulfur from all sources increased, shipments were higher than they had been since 1988, and stocks declined.

Byproduct sulfuric acid from the Nation's nonferrous smelters and roasters, essentially mandated by laws concerning sulfur dioxide emissions, supplied a significant quantity of sulfuric acid to the domestic merchant (commercial) acid market. Production has increased slightly since 1990.

Worldwide, sulfur production increased for the first time since 1988. Frasch production was 17% higher than in 1993, due to increased production in the United States and Poland. Elemental sulfur production from recovered sources, primarily during the processing of natural gas and petroleum products, was virtually unchanged. Nearly three-quarters of the world's elemental sulfur production came from recovered sources; the quantity of sulfur supplied from these sources was dependent on the world demand for fuels and petroleum products, not on the demand for sulfur.

World sulfur consumption was relatively unchanged. Consumption in fertilizer production increased, although consumption for a myriad of industrial uses continued to be pressured by environmental constraints placed on the products produced or effluents from the chemical processes utilizing sulfur or its major derivative, sulfuric acid.

World trade of elemental sulfur was virtually unchanged from the levels recorded in 1993. U.S. sulfur inventories increased about 16% during 1994, however, worldwide inventories of elemental sulfur increased 8%. *(See table 1 and figure 1.)*

Production

Elemental Sulfur.—Elemental sulfur production was about 4% higher in 1994 than it was the previous year; shipments were slightly higher in quantity and 13% higher in value. Increases in the average reported unit value of Frasch sulfur and byproduct sulfuric acid offset decreases in recovered sulfur values.

Production statistics are collected on a monthly basis and published in the USBM Sulfur Monthly Mineral Industry Survey. Of the 149 operations to which a survey request was sent, all responded, representing 100% of the total production shown in table 1.

Frasch.—Native sulfur associated with the cap rock of salt domes and in sedimentary deposits is mined by the Frasch hot-water method, in which the native sulfur is melted underground and brought to the surface by compressed air. In 1994, three Frasch mines operated in Louisiana and Texas, although one of the mines in Louisiana ceased production on January 15, leaving two Frasch operations throughout the remainder of the year. Freeport Sulphur Co. owned and operated two mines in Louisiana, the Caminada Pass Mine, 14 kilometers offshore in the Gulf of Mexico, and Main Pass, 27 kilometers offshore. Caminada was closed to take better advantage of the lower cost sulfur recovery at Main Pass, which had reached full production capacity near the end of 1993. The cost of producing sulfur from Caminada was significantly higher than at Main Pass, and Main Pass alone will supply the company's internal consumption and sales requirements.[2] Pennzoil Sulphur Co. operated at the Culberson Mine in Pecos County, TX.

In October, Pennzoil announced an agreement to sell virtually all of its sulfur assets to Freeport. The sale was effective, officially, January 3, 1995. The sulfur assets included in the sale are the Culberson Mine; sulfur forming and loading facilities in Galveston, TX and Tampa, FL; the charter of a marine sulfur tanker, two sulfur barges, 503 leased and owned sulfur rail cars; and associated commercial contracts and obligations.[3]

Recovered.—Recovered elemental sulfur, a nondiscretionary byproduct from petroleum refining, natural gas processing, and coking plants, was produced primarily to comply with environmental regulations that were applicable directly to emissions from the processing facility or indirectly by restricting the sulfur content of the fuels sold or used by the facility. Recovered elemental sulfur was produced by 59 companies at 150 plants in 26 States, 1 plant in Puerto Rico, and 1 plant in the U.S. Virgin Islands. Most of these plants were of relatively small size, with only 22 reporting an annual production exceeding 100,000 tons. By source, 69% was produced at 3 coking plants and 86 refineries or satellite plants treating refinery gases. The remainder was produced at 61 natural gas treatment plants. The six largest recovered-sulfur producers in 1994 were Exxon Co. U.S.A., Standard Oil Co. (California), Standard Oil Co. (Indiana), Mobil Oil Corp., Star Enterprises, and Shell Oil Co. The 51 plants owned by these companies accounted for 58% of recovered elemental sulfur output during the year. *(See tables 2 and 3.)*

Byproduct Sulfuric Acid.—Byproduct sulfuric acid at copper, lead, molybdenum, and zinc roasters and smelters amounted to 12% of the total domestic production of sulfur in all forms. Eight acid plants operated in conjunction with copper smelters, and eight were accessories to lead, molybdenum, and zinc smelting and roasting operations. The seven largest acid plants (all at copper mines) accounted for 85% of the output. The five largest producers of byproduct sulfuric acid were all copper producers. They were Phelps Dodge Corp., Magma Copper Co., ASARCO Incorporated, Kennecott Corp., and Cyprus Miami Mining Corp. Their eight plants produced 87% of the 1993 total. *(See table 4.)*

Pyrites, Hydrogen Sulfide, and Sulfur Dioxide.—Because the total sulfur contained in these products has not constituted a significant portion of total domestic sulfur production for many years, the surveys that collected data on this production were discontinued for the 1994 canvass.

Consumption and Uses

Domestic consumption of sulfur in all forms was about 5% higher in 1994 than it was in 1993. In 1994, 85% of the sulfur consumed was obtained from domestic sources compared with 83% in 1993, 79% in 1992, 77% in 1991, and 80% in 1990. The sources of supply were domestic elemental sulfur, 76%, and domestic byproduct sulfuric acid, 11%. The remaining 13% was supplied by imports of recovered elemental sulfur.

The USBM collected end-use data on sulfur and sulfuric acid according to the Standard Industrial Classification of industrial activities. Shipments by end use of elemental sulfur were reported by 62 companies, and shipments of sulfuric acid were reported by 55 companies. Shipments of both elemental sulfur and sulfuric acid were reported by 14 companies.

Sulfur differs from most other major mineral commodities in that its primary use is as a chemical reagent rather than a component of a finished product. Its predominant use as a chemical reagent generally required that it first be converted to an intermediate chemical product prior to its initial use by industry. The largest sulfur end use, sulfuric acid, represented 84% of reported consumption with an identified end use. Some identified sulfur end uses were tabulated in the "Unidentified" category because these data were proprietary. Data collected from companies that did not identify shipment by end use also were tabulated as "Unidentified." Although there are no supporting data, it could be reasonably assumed that a significant portion of the sulfur in the "Unidentified" category was shipped to sulfuric acid producers or was exported.

Sulfuric acid, because of its desirable properties, retained its position, both domestically and worldwide, as the most universally used mineral acid and the largest volume inorganic chemical in terms of the quantity produced and consumed. Reported U.S. consumption of sulfur in sulfuric acid (100% basis) was slightly higher in 1994 owing to a 10% increase in demand for sulfuric acid in the production of the phosphoric acid used in the production of phosphate fertilizers, the largest single end use. Sulfuric acid demand for copper ore leaching, the second single largest end use, decreased slightly according to reports from sulfuric acid producers. Reported shipments of sulfur sulfuric acid for petroleum refining and other petroleum and coal products were down 20% from those of 1993.

According to the 1994 canvass reports, company receipt of spent or contaminated sulfuric acid for reclaiming totaled 2.7 million tons. The largest reported source for spent acid was chemical producers with 50% of the total returned. The second largest source of this spent acid was the petroleum refining industry, which accounted for 49% of the total returned. The remaining reclaimed acid was from unidentified sources.

The largest use of sulfur in all forms, for agricultural purposes, increased from 9.0 million tons in 1993 to about 9.9 million tons because of increases in consumption for the production of nitrogenous and phosphatic fertilizers and other agricultural chemicals. Consumption in phosphatic fertilizers was 10% higher than that in 1993, reflecting the improved condition of the phosphate industry. The estimated quantity of sulfur needed to manufacture exported phosphatic fertilizers increased 1 million tons to 5.4 million tons, indicating that consumption for fertilizers intended for domestic consumption was nearly 6% lower than it had been in 1993. *(See tables 5, 6, and 7.)*

Stocks

Yearend inventories held by Frasch and recovered elemental sulfur producers decreased 16% from those of 1993. Combined yearend stocks amounted to approximately a 34-day supply compared with a 43-day supply in 1993, a 23-day supply in 1992, a 34-day supply in 1991, and a 40-day supply in 1990, based on apparent consumption of all forms of sulfur. *(See table 1.)*

Prices

The posted price for Frasch sulfur exterminal Tampa, FL, began the year at $68 per ton, decreased to $65 in February, was quoted as $70 in March, and increased to $77 in October. This price was maintained through yearend. On the basis of total shipments and value reported to the USBM, the average value of shipments for all elemental sulfur was $28.60 per ton in 1994, about 10% lower than in 1993. It is no longer possible to publish average values for the two types of elemental sulfur because there were only two Frasch companies operating in 1994; however, reported Frasch prices increased in 1994 and reported recovered prices decreased. *(See table 8.)*

Foreign Trade

Exports of elemental sulfur from the United States, including the U.S. Virgin Islands, increased 37% in quantity and 22% in value. The average unit value of exported elemental sulfur decreased from $61 per metric ton to $54, a decrease of 11%. According to the Bureau of the Census, exports from the west coast were 611,000 tons or 68% of total U.S. exports.

The United States continued to be a net importer of sulfur; imports exceeded exports by 751,000 tons in 1994. Recovered sulfur from Canada and Mexico delivered to U.S. terminals and consumers in the liquid phase, furnished about 95% of all U.S. sulfur import requirements. Total elemental sulfur imports decreased about 20% in quantity; imports by rail from Canada decreased 27%, while waterborne shipments from Mexico were 11% lower than those in 1993. Imports from several other countries comprised about 5% of all imported sulfur. The value of import elemental sulfur imports increased 24%.

The United States also had significant trade in sulfuric acid. Sulfuric acid exports decreased slightly from those of 1993. Imports were significantly greater than exports, 79% of which were by rail from Canada, 16% waterborne from Europe, and the remainder from several other countries, primarily by ship. The tonnage decreased 13% from the quantity reported in 1993; the value of imported sulfuric acid increased 20%. *(See tables 9, 10, 11, and 12.)*

World Review

Although world production was slightly higher than that of 1993, consumption was down for the sixth consecutive year, and prices were lower in terms of constant dollars than they had been for at least 20 years and probably longer. Frasch production increased for the first time since 1989, recovered sulfur production was relatively unchanged, and byproduct sulfuric acid production grew. Low prices and weak demand prompted worldwide inventory increases, more than one-half of which has been stockpiled in Canada.

Industry Structure.—In 1994, the global sulfur industry remained divided into two sectors, discretionary and nondiscretionary. In one, the mining of sulfur or pyrites was the sole objective; this voluntary production of native sulfur or pyrites was based on the orderly mining of discrete deposits, with the objective of obtaining as nearly a complete recovery of the resource as economic conditions permit. In the other, sulfur or sulfuric acid was recovered as an involuntary byproduct, the quantity of output subject to demand for the primary product irrespective of sulfur demand. In 1994, involuntary sources represented about 67% of the elemental sulfur produced worldwide.

Poland and the United States were the only countries that produced 1 million tons or more of native sulfur using either the Frasch method or conventional mining methods. Small quantities of native sulfur were produced in Asia, Europe, and North and South America. Pyrites have significantly decreased in importance to the world sulfur supply; China, South Africa, and Spain are the only countries in the top 15 sulfur producers whose prime sulfur source is pyrites. Nearly 80% of all pyrites production is in these countries.

Recovered elemental sulfur was the predominant sulfur source in Canada, France, Germany, Iran, Russia, Saudi Arabia, and the United States. Additionally, recovered elemental sulfur was an important source in Japan and Mexico.

International sulfur trade was dominated by a limited number of exporting countries; exports from Canada, Saudi Arabia, Poland, Germany, and Japan, in descending order of the quantity shipped, accounted for 82% of sulfur trade in 1994. Major sulfur importers in 1994 were Morocco, the United States, Tunisia, Brazil, and India, in descending order of importance, all with imports of more than 1 million tons.

Canada.—In 1994, Canada was the world's leading producer of recovered sulfur, primarily from sour gas deposits, and the largest sulfur exporter. Low prices prompted the Canadian export organization, Prism Sulphur Corp., to limit the amount of sulfur made available to the offshore market. This strategy was believed to be partially responsible for the apparent recovery in prices that began in the second half of 1994, but also caused the increase of stocks in Canada to almost 8 million tons. The three largest Canadian suppliers elected to withdraw from Prism at the end of the year to regain control of the marketing of their product. These producers continued to emphasize that their corporate strategy was to continue stockpiling sulfur rather than sell it at less than favorable prices.

Poland.—One of the few major native sulfur producing countries, Poland suffered from reduced sulfur demand and increased supplies since 1989. As Poland has become increasingly market-economy based, environmental concerns in Poland have necessitated increased compliance to environmental protection legislation and energy prices have increased, both factors that drive up the cost of producing sulfur. Poland has restructured its sulfur industry to remain a viable supplier in the world market. Actions have been taken to significantly reduce the cost of production by reducing the amount of hot water required, reducing the work force, and eliminating nonproductive assets, i.e., holiday homes and unused facilities. The responsibility for reclaiming the closed Machow Mine was turned over to the Government and plans exist to convert the mine pit into a recreational boating facility. Three mines remain in operation, Grzybów, Jeziórko, and Osiek. Osiek's first full year of production was 1994.[4] *(See table 13.)*

Current Research and Technology

The first stage of Clean Air Act Amendments (CAAA) of 1990 requires the Nation's largest electric utilities to reduce sulfur dioxide emissions significantly in 1995, and all power companies to limit sulfur dioxide emissions to 1990 levels by the year 2000. Coal-fired power plants are the focus of the acid rain legislation; however, any coal-fired industrial boilers will need to reduce emissions to meet provisions of the CAAA and any State and local requirements. Many companies were developing new and refining existing technologies to meet increasingly stringent environmental regulations.

The most common processes for removing sulfur dioxide from flue gas at existing powerplants have been wet scrubbing systems that produce high volume byproducts or waste materials. However, recent trends in research and development indicate that processes to recover salable byproducts are finding increasing favor as the cost of disposal of the more common waste products is expected to become more costly and more difficult for environmental reasons. Byproducts from new technologies include commercial grade elemental sulfur, sulfuric acid, liquid sulfur dioxide, ammonium sulfate, potassium sulfate, and wallboard-grade synthetic gypsum. Possible market sizes and locations are considered when determining the byproduct of choice. Low value materials, i.e., flue gas desulfurization gypsum, are usually marketed in close proximity to proven markets, while relatively higher value materials such as elemental sulfur may be shipped longer distances as is the case with much recovered sulfur.

A few small and demonstration facilities were producing sulfur products during 1994, and several larger projects should be operating by the end of 1996. The potential exists for significant growth of salable sulfur byproducts as power companies and other industrial coal-burners come into compliance with CAAA requirements and other environmental regulations.

Energy Biosystems Corp. (EBC), of Houston, TX, has developed a unique process for the lowcost removal of sulfur from petroleum products. EBC was building a pilot plant to test its biocatalytic desulfurization process for using genetically engineered microorganisms that remove the sulfur from petroleum products by eating it without consuming carbon and wasting valuable fuel. Construction costs of the biological desulfurizing units are expected to be significantly less expensive than those of the more traditional systems, and operating costs should be lower also. The technology was being piloted on a diesel feedstock supplied by a French petroleum company, and further research was ongoing to investigate the processes potential for desulfurizing crude oil.[5]

Outlook

Although the fortunes of the U.S. sulfur industry were showing signs of improvement in the second half of 1994, the longer term outlook changed little: increased output with slower growth in consumption resulting in variable prices and growing inventories. Specific details are much more difficult. Which producers will suffer most from the oversupply situation is a question that can only be answered over time.

World sulfur demand is forecast to increase at an annual rate of almost 2% per year for the next 10 years. World demand is projected to attain 55.5 million tons in 1999 and increase to just more than 60 million tons in the year 2004. Growth of sulfur consumption in the United States is expected to be modest. The phosphate fertilizer industry was operating near capacity and prospects for significant expansion in this area are low, with expectations for growth reflecting only slight increases to efficiency at operating plants and little chance for new facilities. Industrial consumption should remain fairly steady with the only serious possibility of increases in nonferrous ore leaching.

Almost two-thirds of sulfur consumption in the United States is for agricultural uses. More than 80% of U.S. agricultural sulfur demand and almost 60% of world agricultural sulfur consumption was for the manufacture of phosphoric acid in 1994. World demand for phosphate fertilizers is forecast to increase at an annual rate of about 2.7% for the next 10 years. This indicates improved growth over predictions of the past few years, but is based on the fact that the past few years have been unusually bad for fertilizer producers. It is assumed that more than 80% of the growth will be for the production of phosphoric acid to produce high-analysis fertilizers, which will directly affect world sulfur demand. Consumption of sulfur for phosphate fertilizer manufacture in the United States is divided into two main components: (1) demand for phosphate fertilizers consumed by domestic farmers and (2) demand for exported phosphate fertilizers.

In 1994, an estimate of more than 5 million tons of sulfur was required to manufacture the phosphatic fertilizers exported from the United States compared with about 3.6 million tons of sulfur for domestic phosphoric fertilizer use, based on data reported in the USBM "Phosphate Rock Annual Report." Consumption in the U.S. fertilizer industry is expected to remain relatively steady.

The broad spectrum industrial or nonagricultural sulfur use category accounted for less than one-third of U.S. sulfur consumption and about 40% of world sulfur demand. Although significant variations in demand for the diverse elements within this broad category are expected in the United States and other geographic areas, world industrial demand is expected to average less than a 1% increase annually over the next 10 years, reaching about 23 million tons in the year 2004.

The necessity for the removal of sulfur from solid, liquid, and gaseous effluents for environmental protection has caused the production of sulfur and sulfur compounds from these sources to exceed production from primary sources of supply. The long-term prospect is that 85% or more of the world sulfur supply will come from environmentally regulated sources and that output from these sources will be produced regardless of world sulfur demand. As a result, it is probable that after the turn of the century, no new operation that produces sulfur as its primary product will be developed, except where it may be deemed necessary for political or social reasons and more voluntary operations will be curtailed. In 1980, voluntary sources of production—Frasch, native sulfur, and pyrites—accounted for 50% of world output, about 55 million tons. In 1994, these same sources supplied only 27% of world production, 51.0 million tons.

It is anticipated that in the short term, owing to steady production at Frasch operations and the reluctance of large recovered producers to sell at low prices, world sulfur market availability and demand will be closely balanced; supplies should remain relatively tight through 1995 and going into 1996. However, the number of new recovered facilities continues to grow and more are anticipated to further increase supply availability.

U.S. Frasch production was up in 1994 and is likely to maintain current levels as long as both mines continue to operate. Increases are expected when the United Nations sanctions against Iraq are lifted. The timing and speed of these developments are unknown. Other voluntary producers seem to be maintaining a relatively stable level of production with a slight downward trend. However, recovered sulfur production will continue to expand at a faster pace than demand, and as more countries enact and enforce environmental legislation on a par with North American and European laws, tremendous new quantities of sulfur could be recovered. More stringent regulation and compliance will be long-term developments and cannot be quantified at the current time, but changes are inevitable.

Statistics show that an oversupply situation existed in 1994; however, the decision by some producers to continue to build stocks rather than sell at unfavorable prices resulted in what appeared as tightened supplies and prices rose throughout the year. Material is expected to continue to be withheld from sale through 1995, but as prices rise, the incentive to build inventories lessens and prices could soften. World sulfur production is predicted to reach nearly 64 million tons in 1999 and 67 million tons in 2004.

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TABLE 1
SALIENT SULFUR STATISTICS 1/

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production:					
Frasch	3,730	2,870	2,320	1,900 2/	2,960 e/
Recovered 3/	6,540	6,650	7,050	7,720 r/ 4/	7,160 e/
Other forms	1,300	1,310	1,300	1,430 r/	1,380
Total	11,600	10,800	10,700	11,100 r/	11,500
Shipments:					
Frasch	3,680	3,120	2,600	1,480 2/	W
Recovered 3/	6,480	6,680	7,090	7,580 r/ 4/	10,300 5/
Other forms	1,300	1,310	1,300	1,430 r/	1,380
Total	11,500	11,100	11,000	10,500 r/	11,700
Exports, elemental 6/	972	1,200	966	656	899
Imports, elemental	2,570	3,020	2,730	2,040 r/	1,650
Consumption, all forms	13,100	12,900	12,700	11,800	12,400
Stocks, Dec. 31: Producer, Frasch and recovered	1,420	1,190	809	1,380	1,160
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$335,000	$272,000	$151,000	$101,000	W
Recovered 3/	$479,000	$429,000	$315,000	$189,000 r/	$293,000 5/
Other forms	$117,000	$112,000	$76,100	$63,100 r/	$86,100
Total	$931,000	$813,000	$543,000	$335,000	$379,000
Exports, elemental 6/ 7/	$109,000	$120,000	$69,700	$39,700	$48,400
Imports, elemental 7/	$206,000	$242,000	$130,000	$49,800 r/	$62,000
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$80.14	$71.45	$48.14	$31.86	$28.60
World: Production, all forms (including pyrites)	57,800 r/	54,500 r/	48,500 r/	48,900 r/	51,000 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Recovered."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes 10 months of Frasch sulfur data. Two remaining months of Frasch data included with recovered sulfur data to conform with proprietary data requirements.

3/ Includes Puerto Rico and the U.S. Virgin Islands.

4/ Includes corresponding Frasch sulfur data for November and December.

5/ Includes corresponding Frasch sulfur data.

6/ Includes exports from the U.S. Virgin Islands to foreign countries.

7/ Includes value of exports from the U.S. Virgin Islands to foreign countries.

TABLE 2
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	1993			1994		
		Shipments			Shipments	
	Production	Quantity	Value	Production	Quantity	Value
Alabama	397	397	14,400	406	405	10,600
California	755 r/	747 r/	4,350 r/	764	764	7,170
Illinois	297	295	8,340	303	305	5,200
Louisiana	1,250 2/	1,120 2/	45,000 2/	798 e/	2,930 4/	133,000 4/
Michigan and Minnesota	158	157	733	192	193	2,260
Mississippi	589	580	12,800	612	596	7,320
New Mexico	50	50	321	43	43	54
North Dakota	81	81	1,830	79	79	448
Ohio	54	54	2,420	51	51	859
Pennsylvania	71	71	2,130	98	96	1,780
Texas	2,310 2/	2,310 2/	67,400 2/	2,060	3,110 4/	96,700 4/
Washington	104	107	444	105	105	527
Wyoming	907	909	6,980	963	971	13,300
Other 3/	695	706	21,800	692	692	14,300
Total	7,720 r/	7,580 r/	189,000 r/	7,160 e/	10,300	293,000

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes corresponding Frasch sulfur data for November and December.

3/ Includes Arkansas, Colorado, Delaware, Florida, Indiana, Kansas, Kentucky, Montana, New Jersey, Utah, Virginia, Wisconsin, Puerto Rico, and the U. S. Virgin Islands.

4/ Includes corresponding Frasch sulfur data.

TABLE 3
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICT 1/

(Thousand metric tons)

District and source	1993		1994	
	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	281	280	303	303
Natural gas	47	47	52	52
Total	328	327	355	354
PAD 2:				
Petroleum and coke	721	716	801	803
Natural gas	83	83	79	80
Total	804	799	880	883
PAD 3: 2/				
Petroleum	2,860	2,870	2,800	2,790
Natural gas	1,890 r/ 3/	1,750 r/ 3/	1,210	4,390 4/
Total	4,750 r/	4,620 r/	4,000	7,180
PAD 4 and 5:				
Petroleum	958	950	1,020	1,020
Natural gas	885	886	901	911
Total	1,840	1,840	1,920	1,930
Grand total	7,720 r/	7,580 r/	7,160	10,300

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes Puerto Rico and the U.S. Virgin Islands.

3/ Includes corresponding Frasch sulfur data for November and December.

4/ Includes corresponding data from Frasch producers.

TABLE 4
BYPRODUCT SULFURIC ACID1/ PRODUCED IN THE UNITED STATES 2/

(Thousand metric tons, sulfur content, and thousand dollars)

Type of plant	1993	1994
Copper 3/	1,230 r/	1,200
Zinc 4/	130	118
Lead and molybdenum 4/	66	66
Total	1,430 r/	1,380
Value	63,100 r/	86,100

r/ Revised.

1/ Includes acid from foreign materials.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Excludes acid made from pyrites concentrates.

4/ Excludes acid made from native sulfur.

TABLE 5
CONSUMPTION OF SULFUR 1/ IN THE UNITED STATES 2/

(Thousand metric tons)

	1993	1994
Frasch:		
Shipments	1,480 3/	W
Exports	246	--
Imports	100	--
Total	1,330	W
Recovered:		
Shipments 4/	7,520 5/	10,300 6/
Exports	410	899
Imports	1,940	1,650
Total	9,050	11,100
Total elemental	10,400	11,100
Pyrites, shipments	W	NA
Byproduct sulfuric acid, shipments	1,430 r/	1,380
Other forms, shipments 7/	4	NA
Total, all forms	11,800	12,400

NA Not Available. W Withheld to avoid disclosing company proprietary data; included with "other forms, shipments."

1/ Crude sulfur or sulfur content.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

3/ Includes 10 months of Frasch sulfur data. Two remaining months of Frasch data included with recovered data to conform with proprietary data requirements.

4/ Includes Puerto Rico and the U.S. Virgin Islands.

5/ Includes corresponding Frasch sulfur data for November and December.

6/ Includes data from Frasch producers.

7/ Includes consumption of hydrogen sulfide, liquid sulfur dioxide, and data indicated by symbol W.

TABLE 6

SULFUR AND SULFURIC ACID SOLD OR USED IN THE UNITED STATES, BY END USE 1/

(Thousand metric tons, sulfur content)

End use		Elemental sulfur 2/		Sulfuric acid (sulfur equivalent)		Total	
		1993	1994	1993	1994	1993	1994
102	Copper ores	--	--	696	787	696	787
1094	Uranium and vanadium ores	--	--	1	1	1	1
10	Other ores	--	--	49	34	49	34
20	Food and kindred products	(3/)	--	--	--	--	--
26, 261	Pulpmills and paper products	W	W	304	295	304	295
28, 285, 286, 2816	Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products 4/	74	26	317	240	391	266
281	Other inorganic chemicals	122	127	232	208	354	335
282, 2822	Synthetic rubber and other plastic materials and synthetics	64	W	259	256	323	256
2823	Cellulosic fibers, including rayon	--	--	51	51	51	51
283	Drugs	--	--	15	13	15	13
284	Soaps and detergents	W	8	45	46	45	54
286	Industrial organic chemicals	--	--	82	113	82	113
2873	Nitrogenous fertilizers	--	--	123	145	123	145
2874	Phosphatic fertilizers	--	--	7,910	8,700 p/	7,910	8,700 p/
2879	Pesticides	--	--	7	7	7	7
287	Other agricultural chemicals	914	990 p/	30	36	944	1,030 p/
2892	Explosives	--	--	9	9	9	9
2899	Water-treating compounds	--	--	94	110	94	110
28	Other chemical products	--	--	147	38	147	38
29, 291	Petroleum refining and other petroleum and coal products	571	529	388	236	959	765
30	Rubber and miscellaneous plastic products	W	542	--	--	W	542
331	Steel pickling	--	--	28	10	28	10
333	Nonferrous metals	--	--	26	31	26	31
33	Other primary metals	--	--	2	4	2	4
3691	Storage batteries (acid)	--	--	28	59	28	59
	Exported sulfuric acid	--	--	10	77	10	77
	Total identified	1,740	2,220	11,100	11,500	12,600 r/	13,700
	Unidentified	1,010	94	824	500	1,830	1,040
	Grand total	2,750	2,320	11,900	12,000	14,400 r/	14,800

p/ Preliminary. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Does not include elemental sulfur used for production of sulfuric acid.

3/ Revised to zero.

4/ No elemental sulfur was used in inorganic pigments and paints and allied products.

TABLE 7
SULFURIC ACID FROM SMELTERS SOLD OR USED IN THE UNITED STATES, BY END USE 1/

(Thousand metric tons of 100% H_2SO_4)

SIC	Use	1993	1994
102	Copper ores	1,950	1,920
1094	Uranium and vanadium ores	--	5
10	Other ores	145	105
26, 261	Pulp mills and other paper products	337	51
2816	Inorganic pigments	W	W
281	Other inorganic chemicals	83	95
2823	Cellulosic fibers	W	W
283	Drugs	W	W
2873	Nitrogenous fertilizers	W	W
2874	Phosphatic fertilizers	286	410
287	Other agricultural chemicals	52	82
2899	Water-treating compounds	126	170
28	Other chemical products	16	12
291	Petroleum refining	11	11
331	Steel pickling	W	W
333	Nonferrous metals	12	12
3691	Storage batteries (acid)	16	32
	Unidentified	944	590
	Total domestic	3,980	3,500
	Exports	W	W
	Grand total	3,980	3,500

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 8
REPORTED SALES VALUES OF SHIPMENTS OF SULFUR F.O.B. MINE OR PLANT

(Dollars per metric ton)

	1993	1994
Frasch	51.60	W
Recovered	25.06	W
Average	31.86	28.60

W Withheld to avoid disclosing company proprietary data.

TABLE 9
U.S. EXPORTS 1/ OF ELEMENTAL SULFUR, BY COUNTRY 2/

(Thousand metric tons and thousand dollars)

Country	1993		1994	
	Quantity	Value	Quantity	Value
Argentina	25	779	17	568
Australia	27	2,500	17	1,660
Brazil	116	5,410	157	6,970
Chile	56	2,400	6	280
India	29	1,590	48	1,820
Indonesia	20	1,130	52	2,680
Israel	85	2,660	33	1,720
Korea, Republic of	3	3,810	28	5,270
Mexico	90	6,170	63	3,740
Morocco	8	469	39	1,040
Philippines	6	403	43	2,480
Senegal	33	858	130	5,460
South Africa, Republic of	2	237	56	2,280
Tunisia	93	2,850	62	2,340
Other	63 r/	8,480 r/	148	10,100
Total	656	39,700	899	48,400

r/ Revised.

1/ Includes exports from the U.S. Virgin Islands.

2/ Previously published and 1994 data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 10
U.S. EXPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	3,600	$119	--	--
Canada	89,800	6,190	66,800	$4,690
China	2,130	164	6,220	279
Costa Rica	1,270	97	2,190	144
Dominican Republic	1,740	98	2,880	241
Guatemala	1,280	48	(2/)	17
Israel	3,430	375	6,230	488
Korea, Republic of	1,120	657	(2/)	460
Mexico	14,400	881	11,400	911
Netherlands Antilles	4,360	161	4,880	245
Panama	4,840	144	6,810	239
Singapore	1,060	182	937	201
Taiwan	2,730	606	2,510	769
Trinidad and Tobago	2,220	53	3,640	247
United Kingdom	2,200	126	1,650	54
Venezuela	(2/)	42	7,470	206
Other	8,800 r/	1,230 r/	16,500	1,860
Total	145,000 r/	11,200 r/	140,000	11,100

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS OF ELEMENTAL SULFUR, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

	1993		1994	
Country	Quantity	Value 2/	Quantity	Value 2/
Canada	1,530	27,300	1,120	36,500
Mexico	504	21,300	450	20,900
Other 3/	39 r/	1,200 r/	81	4,640
Total	2,070 r/	49,800 r/	1,650	62,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Declared customs valuation.

3/ Includes France, Germany, Japan, the Netherlands, Netherlands Antilles, and the United Kingdom in 1993; France France, Venezuela, the Netherlands, Japan, Brazil, British Virgin Islands, the Dominican Republic in 1994.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY 1/

	1993		1994	
Country	Quantity (metric tons)	Value 2/ (thousands)	Quantity (metric tons)	Value 2/ (thousands)
Canada	1,380,000 r/	$52,600 r/	1,680,000	$72,900
Germany	369,000 r/	5,450 r/	264,000	5,680
Italy	23,100	503	--	--
Japan	224,000	4,080	103,000	2,880
Mexico	121,000 r/	2,450 r/	18,600	1,350
Netherlands	81,200	1,570	27,600	671
Spain	75,000	1,710	984	91
Sweden	59,100	1,360	29,700	1,130
United Kingdom	96,000 r/	876 r/	11,000	374
Other	9,980 r/	63 r/	73	23
Total	2,440,000 r/	70,700 r/	2,130,000	85,100

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Declared c.i.f. valuation.

Source: Bureau of the Census.

TABLE 13
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE 1/ 2/

(Thousand metric tons)

Country and source 3/	1990	1991	1992	1993	1994 e/
Canada: Byproduct:					
Metallurgy	899	872	931	897 r/	990 4/
Natural gas	5,180	5,490	5,770	6,500 e/	7,000
Petroleum e/	207 4/	230	235	350 r/	400
Tar sands	503	540	552	700 r/	750
Total e/	6,790	7,130	7,490	8,450 r/	9,140 4/
China: e/					
Native	320	320	320	330	330
Pyrites	4,400	4,940	4,500	5,000	5,000
Byproduct, all sources	650	650	650	700	700
Total	5,370	5,910	5,470	6,030	6 030
France: Byproduct:					
Natural gas	666	794	770	829 r/	700
Petroleum	233 e/	225	230	278 r/	250
Unspecified e/	150	180	150	150	150
Total e/	1,050	1,200	1,150	1,260 r/	1,100
Germany:					
Pyrites e/	150	95	25	--	--
Byproduct:					
Metallurgy	225 r/	23 r/	23	33 r/	35
Natural gas and petroleum	915 r/	1,080 r/	1,020	1,140 r/	1,200
Unspecified 5/	260 e/	84	100	XX	XX
Total e/	1,550	1,280	1,160	1,170 r/ 4/	1,240
Iran: Byproduct: e/					
Metallurgy	45	50	50	50	50
Natural gas and petroleum	635	650	700	750	830
Total	680	700	750	800	880 4/
Iraq: e/					
Frasch	800	250	500	600	600
Byproduct, natural gas and petroleum	380	50	100	200	200
Total	1,180	300	600	800	800
Japan:					
Pyrites	53	30	31	29	4 4/
Byproduct:					
Metallurgy	1,310 r/	1,350 r/	1,370 r/	1,380 r/	1,350
Petroleum	1,270	1,240	1,340 r/	1,510 r/	1,550
Total	2,630 r/	2,630 r/	2,750 r/	2,920 r/	2,900
Mexico:					
Frasch	1,440	1,040	710	102	--
Byproduct:					
Metallurgy e/	290	280	817	730 r/	2,010 4/
Natural gas and petroleum	682	754	775	804 r/	877 4/
Unspecified	--	20	--	30 e/	30
Total e/	2,410	2,094 r/	2,300	1,670 r/	2,920
Poland: 6/					
Frasch	4,030	3,300	2,280	1,850 r/	2,100
Native	637	633	635	40 r/	41
Byproduct: e/					
Metallurgy	200	200	200	200	200
Petroleum	28	28	25	25	25
Gypsum e/	10	10	10	10	10
Total e/	4,900	4,170	3,150	2,130 r/	2,380
Russia: e/ 7/					
Native	XX	XX	100	100	80
Byproducts:					
Metallurgy	XX	XX	250	200	150
Natural gas	XX	XX	1,800	1,700 r/	1,600
Total	XX	XX	2,150	2,000 r/	1,830
Saudi Arabia: Byproduct, natural gas and petroleum	1,435	2,000	1,630	1,600 e/	1,600

See footnotes at end of table.

TABLE 13--Continued

SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE 1/ 2/

(Thousand metric tons)

Country and source 3/	1990	1991	1992	1993	1994 e/
South Africa, Republic of:					
Pyrites	452	293	296 r/	323 r/	252 4/
Byproduct:					
Metallurgy e/	21 r/	68 r/	56 r/	81 r/	82
Petroleum 8/	210 r/ e/	160 r/ e/	166 r/	171 r/	190 4/
Total	683	521 r/	518 r/	575 r/	524 4/
Spain:					
Pyrites	748	546	510	327 e/	350
Byproduct: e/					
Coal (lignite) gasification	2	2	2	2	2
Metallurgy	248	252	258	258	250
Petroleum	149	105	90	100	100
Total e/	1,150	905	860	687	702
U.S.S.R.: e/ 9/					
Frasch	1,000	900	XX	XX	XX
Native	2,000	1,800	XX	XX	XX
Pyrites	1,900	1,700	XX	XX	XX
Byproduct:					
Metallurgy	1,200	1,100	XX	XX	XX
Natural gas	2,500	2,200	XX	XX	XX
Petroleum	425	400	XX	XX	XX
Total	9,030	8,100	XX	XX	XX
United States:					
Frasch	3,730	2,870	2,320	1,900 10/	2,930
Pyrites	W	W	W	W	(11/)
Byproduct:					
Metallurgy	1,290	1,300	1,290	1,390	1,400
Natural gas	2,340	2,400	2,530	2,850 12/	2,240 4/
Petroleum	4,200	4,240	4,520	4,820	4,920 4/
Unspecified	4	4	3	3	(11/)
Total	11,600	10,800	10,700	11,000	11,500
Other countries:	7,410	6,780	7,810	7,840	7,430
Of which:					
Frasch	6	5	18	20	20
Native	97	94	960	790	622
Pyrites	2,330	1,920	1,740	1,600	1,480
Byproduct:					
Coal (lignite) gasification	--	--	--	--	--
Metallurgy	1,940	2,000	2,140	2,250	2,010
Natural gas	272	246	277	299	303
Natural gas and petroleum, undifferentiated	597	370	486	490	531
Petroleum	1,230	1,270	1,370	1,550	1,620
Tar sands	--	--	--	--	--
Unspecified sources	934	880	817	839	840
Gypsum	--	--	--	--	--
Grand total:	57,800 r/	54,500 r/	48,500 r/	48,900 r/	51,000
Of which:					
Frasch	11,000	8,370	5,830 r	4,480 r/	5,650
Native	3,050	2,850	2,020 r/	1,260 r/	1,070
Pyrites	10,000 r/	9,520 r/	7,110 r/	7,280 r/	7,090
Byproduct:					
Coal (lignite) gasification	2	2	2	2	2
Metallurgy	7,670 r/	7,500 r/	7,390 r/	7,470 r/	8,540
Natural gas	11,000	11,100	11,100 r/	12,200 r/	11,800
Natural gas and petroleum, undifferentiated	4,640 r/	4,900 r/	4,710	4,980 r/	5,240
Petroleum	7,950 r/	7,900	7,980 r/	8,800 r/	9,060
Tar sands	503	540	552	700 r/	750
Unspecified sources	2,000	1,820 r/	1,720	1,720 r/	1,720
Gypsum	10	10	10	10	10

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Byproduct: Unspecified sources." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 12, 1995.

3/ The term "Source" reflects both the means of collecting sulfur and the type of raw material. Sources listed include the following: (1) Frasch recovery; (2) native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); (3) pyrites (whether or not the sulfur is recovered in the elemental form or as acid); (4) byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, tar sand cleaning, and processing of spent oxide from stack-gas scrubbers; and (5) recovery from the processing of mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded because to include it would result in double counting. It should be noted that production of Frasch sulfur, other native sulfur, pyrites-derived sulfur, mined gypsum-derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from tar sands are all credited to the country of origin of the extracted raw materials, in contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which in some instances is not the original source country of the crude product from which the sulfur is extracted.

4/ Reported figure.

5/ Data for 1990-92 represent byproduct production from the eastern states. Production data for 1993-94 represent those of the unified country.

6/ Official Polish sources report total Frasch and native mined elemental sulfur output annually, undifferentiated; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources.

7/ Sulfur is believed to be produced from Frasch and pyrite, and as a petroleum byproduct, however information is inadequate to formulate reliable estimates.

8/ Estimates for 1990-94 include byproduct production from synthetic fuels.

9/ Dissolved in Dec. 1991.

10/ Includes 10 months of Frasch sulfur production data. Two remaining months of Frasch data included with byproduct: natural gas data to conform with proprietary data requirements.

11/ Survey discontinued for 1994; data not available.

12/ Includes Frasch sulfur production data for November and December.

TALC AND PYROPHYLLITE

By Robert L. Virta

The mineral talc is a hydrous magnesium silicate. A massive talcose rock is called steatite and an impure massive variety is referred to as soapstone. Talc is used commercially because of its softness, purity, fragrance retention, whiteness, luster, moisture content, oil and grease adsorption, chemical inertness, low electrical conductivity, high dielectric strength, and high thermal conductivity. Major markets for talc include ceramics, paint, and paper.

Pyrophyllite is a hydrous aluminum silicate with a structure similar to talc. Properties such as softness, whiteness, chemical inertness, high melting point, low electrical conductivity, and high dielectric strength make pyrophyllite useful for ceramic and refractory applications.

Domestic production and sales data for talc and pyrophyllite are developed by the U.S. Bureau of Mines (USBM) from a voluntary survey of U.S. mines and mills. Survey forms were sent to 15 companies. Twelve companies that account for approximately 95% of the domestic production responded to the survey. Production data for the nonrespondents were estimated from reported prior-year production levels adjusted by trends in the industry and other guidelines. *(See table 1.)*

Legislation and Government Programs

The Mine Safety and Health Administration (MSHA) continued to review its proposed revisions to its air quality, chemical substances, and respiratory protection standards. The proposed permissible 8-hour time-weighted average exposure limit is 2.5 milligrams per cubic meter (mg/m^3) of air for talc (containing no asbestos), 3 mg/m^3 for respirable soapstone, and 6 mg/m^3 for total soapstone dust. The nonasbestiform varieties of tremolite, anthophyllite, and actinolite would be covered under the proposed respirable mine dust standard.[1]

MSHA continued reviewing its proposed rule that would create a hazard communication standard. Mine operators would be required to provide information to their employees through labeling, material safety data sheets, and employee training if hazardous chemicals were produced or used on the premises.

Production

Talc.—Twelve companies operating 16 mines in 7 States produced talc, soapstone, and steatite. These companies generally were structured to cover all aspects of talc production, from mining to processing. Only a few companies hired custom grinders to mill the ore. The largest domestic producers, ranked in decreasing order, were Luzenac America Inc., Gouverneur Talc Co., Barretts Minerals Inc., and Dal Minerals.

U.S. mine production of crude talc was 935,000 tons, valued at $30.4 million in 1994. *(See tables 1 and 2.)* Production in Montana and New York increased while that of California, Texas, Vermont, and Virginia decreased. Mines that operated in Montana, New York, Texas, and Vermont accounted for 96% of domestic talc production. Montana led all States in the tonnage and value of talc produced, followed by Texas, Vermont, New York, California, Virginia, and Oregon, in decreasing order of production.

Luzenac America Inc. purchased Montana Talc Co., a subsidiary of Costain PLC. Luzenac America closed Montana Talc's mine but will continue to operate the mill at Sappington, MT.[2]

Zemex Corp. (Canada) purchased the Pioneer Talc Co. talc mining and milling operation in Van Horn, Texas. Pioneer Talc was owned by Whittaker, Clark, and Daniels Inc.[3]

Pyrophyllite.—Pyrophyllite was mined by two companies operating three mines in North Carolina and one company operating one mine in California. U.S. mine production of crude pyrophyllite increased 20% from that of 1993.

Consumption

Talc.—Domestic producers reported that overall sales (including exports by producers) was 923,000 tons, valued at $116 million in 1994. *(See table 1.)* Domestic markets for talc were in ceramics (pottery, sanitaryware, tiles, etc.), paint, paper, plastics, roofing, cosmetics, rubber, insecticides, and refractories, in decreasing order of consumption. *(See table 3.)*

Consumption of talc in ceramics and paper increased slightly from that of 1993. The cosmetic and paint markets remained stable. Small decreases were reported for insecticide and rubber markets. The use of talc in plastics continued to grow, with consumption approaching levels last observed in 1990. A large decrease was reported for roofing applications, where competition from competing minerals affected the markets.

Approximately 97,000 tons of talc were reported under the "Other" category by respondents. Of this amount, 8,000 tons were used in automobile body fillers, food or medicines, and sculpture media and 70,000 tons were used in caulks, joint compounds, paint, and putties, and vinyl sheet and tile flooring. Approximately 19,000 tons of talc were used in applications that were not identified by respondents.

More than 90% of the data presented in table 3 was reported by the companies, the remainder was estimated from reported prior-year data adjusted according to industry trends.

An additional 155,000 tons of imported talc were not included in the end- use breakdown shown in table 3. The imported talc was purchased primarily by mineral brokers who do not participate in the USBM survey. A large percentage of the imported talc was believed to have been used in plastics. Imports amount to 17% of the total domestic consumption.

Pyrophyllite.—Domestic consumption of pyrophyllite increased 20% from that of 1993. The largest portion of domestically produced ground pyrophyllite was used in ceramics, followed by refractories, paint, plastics, insecticides, and rubber, in decreasing order of consumption.

Prices

Talc prices varied depending on the quality and on the degree and method of processing. The unit value of crude talc based on data reported by producers was $33 per ton. The average reported unit value of processed talc was $126 per ton. The average unit value of crude and processed pyrophyllite was essentially unchanged from that of 1993.

Unit values for imported crude and ground talc ranged from $42 per ton to $815 per ton for shipments exceeding 100 tons. Unit values for cut or sawed talc ranged from $416 per ton to $805 per ton for shipments exceeding 100 tons. The average unit value for all shipments, including those of 100 tons or less, was $80 per ton for crude talc; $82 per ton for ground talc; and $1,172 per ton for cut or sawed talc. The average unit value for cut or sawed talc was extremely high because of the large number of low tonnage-high value shipments made during the year. The average unit value for all imported talc was $96 per ton.

Unit values for exported talc ranged from $71 per ton to $499 per ton for shipments exceeding 100 tons and averaged $180 per ton for unground talc and $195 per ton for ground talc. The average value for all exported talc was $194 per ton for all exports. The unit values for the crude and unground talc categories for imports and exports were greater than expected because of several low tonnage-high value ($237 to $5,000 per ton) shipments made during the year. These shipments were probably sculpture-grade steatite, surface-treated talc, and/or talcum powder products.

Prices, quoted by the American Paint & Coatings Journal, December 28, 1994, in U.S. dollars per metric ton for paint-grade talc in carload lots ranged from $99 to $220. Approximate equivalents, in dollars per metric ton, of price ranges quoted in Industrial Minerals (London), December 1994, for talc, c.i.f. main European ports, ranged from $92 to $330. *(See table 4.)* Quoted prices should be used only as a guideline because they depend on the terms of the contract between seller and buyer.

Foreign Trade

Talc exports increased 14% in tonnage from 135,000 tons to 154,000 and 10% in value from $27.2 million to $29.8 million. Canada was the largest importer of talc, followed by Mexico, Belgium-Luxembourg, Japan, the Republic of Korea (7,637 tons), and Germany (5,475 tons). *(See table 5.)* Talc imports increased 55% in tonnage from 100,000 tons to 155,000 tons and increased 38% in value from $10.8 million to $14.9 million. Canada, China, and Japan supplied 85% of all talc imports. *(See table 6.)* Most of the talc imported from Japan was likely to have been transshipments from other Southeast Asian countries.

World Review

China is the world's largest producer of talc, followed by the United States and Finland, in decreasing order of production. Japan was the largest producer of pyrophyllite, followed by the Republic of Korea and Brazil. China, Japan, and the United States produced 55% of the world's talc and pyrophyllite. *(See table 7.)* Among the activities taking place in 1994 was the purchase of Finnminerals Oy by United Paper Mills and expansion of Haicheng Talc Mines Co.'s operations in Liaoning province.

Outlook

Domestic consumption of talc should grow slowly as the economy improves. Ceramics will continue to be the major domestic end use for talc, followed by paper, paint, roofing, plastics, and cosmetics, in descending order. For pyrophyllite, the major domestic end uses will continue to be in ceramics and refractories.

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[1] Federal Register. Mine Safety and Health Administration. Air Quality, Chemical Substances, and Respiratory Protection Standards. V. 56, No. 39, Feb. 27, 1991, pp. 8168-8171.

[2] Montana Standard (Bozeman). Luzenac Buys, Then Closes, Talc Mine. May 26, 1994, p. 1.

[3] Chemical Marketing Reporter. Talc Purchase Completed. V. 246, No. 25, Dec. 19, 1994, p. 7.

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TABLE 1
SALIENT TALC AND PYROPHYLLITE STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Mine production, crude:					
Talc	1,190	1,040	997	968	935
Pyrophyllite	82	W	W	W	W
Total	1,270	1,040	997	968	935
Value					
Talc	$31,100	$32,100	$31,300	$27,800	$30,400
Pyrophyllite	W	W	W	W	W
Total	$31,100	$32,100	$31,300	$27,800	$30,400
Sold by producers, crude and processed:					
Talc	1,020	864	817	900	923
Pyrophyllite	80	W	W	W	W
Total	1,100	864	817	900	923
Value					
Talc	W	$82,600	$94,700	$104,000	$116,000
Pyrophyllite	W	W	W	W	W
Total	$111,000	$82,600	$94,700	$104,000	$116,000
Exports 2/ (talc)	200	178	175	135	154
Value	$29,200	$30,100	$30,100	$27,200	$29,800
Imports for consumption	65	67	80	100	155
Value	$11,100	$11,900	$12,400	$10,800	$14,900
Apparent consumption	1,050	926	902 3/	933 3/	936 3/
World: Production	9,370 r/	9,070 r/	8,760 r/	8,700 r/	7,890 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes powders--talcum (in package), face, and compact.

3/ Production, plus imports, minus exports, plus adjustments in Government and industry stock. Does not include pyrophyllite.

TABLE 2
CRUDE TALC PRODUCED IN THE UNITED STATES, BY STATE 1/ 2/

(Thousand metric tons and thousand dollars)

State	1993		1994	
	Quantity	Value	Quantity	Value
Montana	350	11,900	W	W
Texas	236	5,660	225	5,860
Oregon	(3/)	67	W	W
Other 4/	382	10,200	710	24,600
Total	968	27,800	935	30,400

W Withheld to avoid disclosing company proprietary data; not included in "Total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes pyrophyllite.

3/ Less than 1/2 unit.

4/ Includes Arkansas (1993), California, Montana (1994), New York, Oregon (1994), Vermont, and Virginia.

TABLE 3
END USES FOR GROUND TALC AND PYROPHYLLITE 1/

(Thousand metric tons)

Use	1993			1994		
	Talc	Pyrophyllite	Total	Talc	Pyrophyllite	Total
Ceramics	253	W	253	265	W	265
Cosmetics 2/	31	--	31	31	--	31
Insecticides	7	W	7	6	W	6
Paint	141	W	141	142	W	142
Paper	110	W	110	121	W	121
Plastics	27	W	27	45	W	45
Refractories	--	W	--	(3/)	W	(3/)
Roofing	68	--	68	38	--	38
Rubber	21	W	21	19	W	19
Other 4/	114	W	114	97	W	97
Total	770	W	770	764	W	764

W Withheld to avoid disclosing company proprietary data.

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Incomplete data. Some cosmetic talc known to be included in "Other."

3/ Less than 1/2 unit.

4/ Includes art sculpture, asphalt filler, auto body filler, construction caulks, joint compounds, flooring, food additives, and other uses not specified.

TABLE 4
PRICE OF TALC

(U.S. dollars per metric ton)

	Value
Canada: Fine micron, Hegman No. 6	205
Montana: Ultrafine grind. Hegman No. 6	220
New York:	
Bags, mill:	
98% through 325 mesh	99
99.6% through 325 mesh	115
Trace retained on 325 mesh	180
Italian, cosmetic-grade	263
Chinese, normal (ex-store):	
UK 200 mesh	285-323
UK 350 mesh	300-330

Sources: American Paint & Coatings Journal, Dec. 27, 1994, and Industrial Minerals (London), Dec. 1994.

TABLE 5
U. S. EXPORTS OF TALC 1/ 2/

(Thousand metric tons and thousand dollars)

Country	1993 Quantity	1993 Value	1994 Quantity	1994 Value
Belgium	10	$2,080	10	$1,210
Canada 3/	47	8,740	54	9,930
Japan	7	958	8	1,330
Mexico	12	1,770	13	2,210
Other 4/	59	13,600	69	15,200
Total	135	27,200	154	29,800

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes powder--talcum (in package), face, and compact.

3/ Probably includes shipments in transit through Canadian ports.

4/ Includes 67 countries in 1993 and 62 countries in 1994.

Source: Bureau of the Census.

TABLE 6
U.S.IMPORTS FOR CONSUMPTION OF TALC, BY COUNTRY 1/

Country	Not crushed or powdered		Crushed or powdered		Cut and sawed		Total unmanufactured	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993:								
Brazil	--	--	114	$25	264	$155	378	$179
Canada	38	$11	27,900	4,480	918	888	28,900	5,380
China	36,800	1,650	2,120	257	675	360	39,600	2,270
France	--	--	2,940	288	(2/)	3	2,940	290
Japan	--	--	20,300	706	1	2	20,300	708
Other 3/	6,670	604	554	283	441	1,050	7,660	1,940
Total	43,500	2,270	54,000	6,040	2,300	2,460	99,800	10,800
1994:								
Brazil	3	3	97	25	250	164	350	192
Canada	272	49	31,000	5,280	600	598	31,900	5,930
China	50,200	2,140	5,360	452	705	346	56,200	2,940
France	620	505	3,090	314	10	5	3,720	824
Japan	8	171	43,200	745	2	4	43,200	920
Other 4/	14,200	2,340	4,510	330	647	1,470	19,300	4,140
Total	65,200	5,210	87,300	7,150	2,210	2,590	155,000	14,900

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Includes 21 countries.

4/ Includes 24 countries.

Source: Bureau of the Census.

TABLE 7
TALC AND PYROPHYLLITE: WORLD PRODUCTION, BY COUNTRY AND PRODUCT 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina:					
Pyrophyllite	-- r/	-- r/	-- r/	-- r/	--
Steatite	200 r/	274 r/	425 r/	840 r/	500
Talc	17,800 r/	22,800 r/	21,200 r/	17,200 r/	17,300
Australia: e/					
Pyrophyllite	5,000	6,000	5,000	5,000	5,000
Talc	200,000	210,000	210,000	210,000	210,000
Austria: Steatite	134,000	161,000	146,000	137,000 r/	130,000
Brazil:					
Pyrophyllite	165,000	186,000	144,000	150,000 e/	150,000
Talc	280,000	292,000	286,000	290,000 e/	290,000
Canada: Pyrophyllite, soapstone, talc e/	148,000	123,000	104,000	108,000 r/	130,000 4/
Chile: Talc	898	536	1,490 r/	5,060 r/	3,000
China: Unspecified e/	2,550,000	2,600,000	2,650,000	2,700,000	2,400,000
Colombia: Pyrophyllite, soapstone, talc	10,100	11,100	13,300	19,600 r/	20,000
Egypt: Pyrophyllite, soapstone, steatite, talc	6,340	9,090	9,000 e/	2,090 r/	2,000
Finland: Talc	385,000	361,000	371,000	399,000 r/	400,000
France: Talc e/	328,000 4/	310,000	300,000	280,000 r/	275,000
Germany: Talc (marketable)	21,400	22,600	23,500	21,200 r/	20,000
Greece: Steatite	1,440	790	700 e/	700 e/	500
Hungary: Talc e/	10,000	10,000	10,000	10,000	10,000
India:					
Pyrophyllite	80,000 e/	84,600	85,000 e/	81,600 r/	82,000
Steatite e/	406,000	424,000	425,000	360,000 r/ 4/	360,000
Iran: Talc 5/	31,100	6,680	23,700	18,000 r/	18,000
Italy: Steatite and talc	152,000	161,000	184,000 r/	165,000 e/	150,000
Japan:					
Pyrophyllite	1,210,000	1,230,000	1,060,000	1,030,000 r/	936,000 4/
Talc	61,600	65,600	61,000	57,200 r/	63,100 4/
Korea, North: Unspecified e/	170,000	170,000	170,000	180,000	180,000
Korea, Republic of:					
Pyrophyllite	658,000	573,000	603,000	645,000 r/	650,000
Talc	182,000	171,000	150,000	53,900 r/	60,000
Macedonia: Talc e/ 6/	XX	XX	15,000	10,000	10,000
Mexico: Talc	13,500	11,900	19,600	14,400 r/	15,000
Nepal: Talc 7/	1,800	3,170 r/	3,820 r/	1,340 r/	1,500
Norway: Talc e/	100,000	80,000	60,000	50,000	50,000
Pakistan: Pyrophyllite	30,200	33,600	23,700	46,800 r/	45,000
Paraguay: Unspecified e/	200	200	200	200	200
Peru: e/					
Pyrophyllite	7,500	8,000	8,000	8,000	8,000
Talc	1,500	2,100	2,000	2,000	2,000
Portugal: Talc	7,930	8,000 e/	9,170 r/	9,350 r/	9,000
Romania: Talc e/	20,000	10,000	6,330 4/	6,500	6,500
Russia: Talc	XX	XX	150,000 e/	132,000	100,000
South Africa, Republic of:					
Pyrophyllite	2,760	4,450	3,050	4,290 r/	4,110 4/
Talc	11,200	8,240	13,900	8,800 r/	6,850 4/
Spain: Steatite e/	70,000	70,000	70,000	65,000	65,000
Sweden: Talc	15,000	19,200	10,000 r/ e/	-- r/ e/	--
Taiwan: Talc	22,100	18,500	6,090	5,020 r/	5,000
Thailand:					
Pyrophyllite	29,300	43,000	34,600	43,400 r/	38,000
Talc	4,360	5,580	4,790	7,010 r/	5,000
Turkey	5,560	6,120	3,920	4,000 e/	4,000
U.S.S.R.: Talc e/ 8/	500,000	450,000	XX	XX	XX

See footnotes at end of table.

TABLE 7--Continued
TALC AND PYROPHYLLITE: WORLD PRODUCTION, BY COUNTRY AND PRODUCT 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
United Kingdom: Talc, soapstone, pyrophyllite	14,800	10,800	5,220	5,320 r/	5,500
United States:					
Pyrophyllite	82,000	W	W	W	W
Talc	1,190,000	1,040,000	997,000	968,000	935,000 4/
Uruguay: Talc, soapstone, pyrophyllite e/	1,500	1,500	1,500	1,500	1,500
Yugoslavia: Talc 6/ 9/	18,000	17,000 e/	XX	XX	XX
Zambia: Talc	160	89	336	350 e/	350
Zimbabwe: Talc	1,790	1,680	2,200	1,350 r/	1,500
Total	9,370,000 r/	9,070,000 r/	8,510,000 r/	8,340,000 r/	7,880,000
Of which:					
Pyrophyllite	2,270,000 r/	2,170,000	1,970,000 r/	2,010,000 r/	1,920,000
Steatite	612,000 r/	656,000	642,000	564,000 r/	556,000
Talc	3,430,000 r/	3,150,000 r/	2,760,000 r/	2,580,000 r/	2,510,000
Unspecified	3,060,000	3,090,000	3,140,000 r/	3,190,000 r/	2,890,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

/ Table includes data available through May 15, 1995.

2/ In addition to the countries listed, the former Czechoslovakia produces talc, but information is inadequate to make reliable estimates of output levels.

4 /Reported figure.

5/ Data based on Iranian fiscal year beginning Mar. 21 of year stated.

6/ All production in Yugoslavia from 1990-91 came from Macedonia.

7/ Data based on Nepalese fiscal year beginning mid-July of year stated.

8/ Dissolved in Dec. 1991; however, information is inadequate to formulate reliable estimates for individual countries, except Russia.

9/ Dissolved in Apr. 1992.

THORIUM

By James B. Hedrick

Thorium is the 39th most abundant of the common elements (78) in the Earth's crust at 7.2 parts per million. It is a soft, very ductile, silvery-white metal that emits radioactive alpha particles. Th^{232} has a very long half-life of 1.389×10^{10} years. The metal weighs about six times as much as magnesium and has a very high melting point. Thorium oxide, which is also called thoria, has the highest melting point of all the oxides. Its high-temperature properties are used in the manufacture of high-strength, high-temperature alloys and in refractory ceramics. Domestic consumption of refined thorium products increased, according to the Bureau of Mines, U.S. Department of the Interior. The value of thorium metal and compounds used by the domestic industry correspondingly increased and was estimated to be about $250,000. Thorium production was primarily from the rare-earth ore mineral, monazite, a byproduct of processing heavy-mineral sands for titanium and zirconium minerals or tin minerals. Thorium compounds were produced from monazite during processing for the rare earths. Only a small portion of the thorium produced is consumed; most is discarded as waste.

Limited demand for thorium, relative to the rare earths, continued to create an extensive world oversupply of thorium compounds and residues. Several major rare-earth processors have switched feed materials to thorium-free intermediate compounds. Excess thorium, not designated for commercial use, was either disposed of as a radioactive waste or stored for potential use as a nuclear fuel or other application. Major nonenergy uses have shifted from refractories to lighting and welding electrodes.

Problems associated with thorium's natural radioactivity represented a significant cost to those companies involved in its mining, processing, manufacture, and use. Increased costs to comply with environmental regulations and to purchase storage and waste disposal space were the principal deterrents to its commercial use. According to industry sources, health concerns associated with thorium's natural radioactivity, which is solely alpha emissions, have not been factor in switching to alternative non-radioactive materials.

Legislation and Government Programs

The calendar year 1994 included the U.S. Government fiscal years for 1994 and 1995. Public Law 103-160, the National Defense Authorization Act for Fiscal Year 1994, was enacted on November 30, 1993, and covered the year 1994 through September 30. It continued the previous authorization for disposal of all stocks of thorium nitrate in excess of the National Defense Stockpile (NDS) goal of 272,155 kilograms (600,000 pounds). The National Defense Authorization Act for Fiscal Year 1995, Public Law 103-337, was enacted on October 5, 1994, and covered the last 3 months of 1994. It continued authorization for disposal of 2,947,301 kilograms (6,497,687 pounds) of thorium nitrate classified as excess to goal.

Production

Domestic mine production data for thorium-bearing monazite are developed by the U.S. Bureau of Mines from a voluntary survey of U.S. operations entitled the Rare Earths, Thorium, and Scandium. The one mine to which a survey form was sent responded, representing 100% of domestic production. Mine production data for thorium are withheld to avoid disclosing company proprietary data.

RGC (USA) Minerals Inc., a wholly owned subsidiary of the Australia-based Renison Goldfields Consolidated Ltd., operated a dredging operation at Green Cove Springs, FL. RGC (USA) recovered monazite for its rare-earth content as a byproduct during processing for titanium and zirconium minerals. Byproduct monazite production decreased 27% from the previous years level, amid decreased demand for thorium-bearing rare-earth ores.

None of the domestically produced monazite was processed in the United States for its thorium content. The largest previous domestic processor of monazite, Grace Davison, (previously Davison Specialty Chemical Co.) in Chattanooga, TN, continued to use thorium-free rare-earth chloride and rare-earth concentrates as feed materials.

Essentially all thorium alloys and compounds used by the domestic industry were derived from either imports, company stocks, or U.S. Government stockpiles. Domestic companies processed or fabricated various forms of thorium for nonenergy uses such as ceramics, incandescent lamp mantles, carbon arc lamps, magnesium-thorium alloys, refractories, and welding electrodes.

Consumption

Statistics on domestic thorium consumption are developed by surveying various processors and manufacturers, evaluating import-export data, and analyzing Government stockpile shipments. *(See table 1.)*

Domestic thorium producers reported consumption of 17.3 metric tons of thorium oxide equivalent in 1994, an increase of 4.5 tons from the 1993 level. Nonenergy uses accounted for essentially all of the total consumption. Increased consumption was primarily the result of increased demand for thorium in carbon arc lighting. The approximate distribution of thorium by end use, on an equivalent oxide basis, based on data supplied by processors and several consumers, was as follows: lighting, 90%; welding electrodes, 8%; ceramics and refractories, 2%; metallurgical applications, <0.5%.

Thorium oxide (thoria) has the highest melting point of all the metal oxides, 3,300° C. This property contributed to its use in several refractory applications. High-temperature uses were in ceramic parts, investment molds, and crucibles.

Thorium fluoride was used in the manufacture of carbon arc lamps. Carbon arc lamps were used in searchlights, movie projectors, and cinematography lighting to provide a high-intensity white light.

Thorium nitrate was used in the manufacture of mantles for incandescent "camping" lanterns, including natural gas lamps and oil lamps. Thorium mantles provide an intense white light which is adjusted towards the yellow region by a small addition of cerium. Thoriated mantles were not produced domestically due to the development of a suitable thorium-free substitute.

Thorium nitrate also was used to produce thoriated tungsten welding electrodes. Thoriated tungsten welding electrodes were used to join stainless steels, nickel alloys, and other alloys requiring a continuous and stable arc to achieve precision welds.

The nitrate form also was used to produce thoriated tungsten elements used in the negative poles of magnetron tubes. Thorium was used because of its ability to emit electrons at relatively low temperatures when heated in a vacuum. Magnetron tubes were used to emit electrons at microwave frequencies to heat food in microwave ovens and in radar systems used to track aircraft and weather conditions.

Thorium was used in other types of electron emitting-tubes, elements in special use light bulbs, high-refractivity glass, radiation detectors, computer memory components, catalysts, photo conductive films, target materials for x-ray tubes, and fuel cell elements.

In metallurgical applications, thorium was alloyed with magnesium. Magnesium—thorium alloys used by the aerospace industry are lightweight, have high-strength, and excellent creep resistance at elevated temperatures. Thorium-free magnesium alloys have been developed with similar properties and are expected to replace most of the thorium-magnesium alloys presently used. Small quantities of thorium were used in dispersion hardened alloys for high-strength, high-temperature applications.

Thorium was used as a nuclear fuel in the thorium-232/uranium-233 fuel cycle. Only a few foreign-based nuclear reactors continued to operate with this fuel cycle. The use of thorium as a nuclear fuel is not expected to grow due to the current availability of low cost uranium.

Stocks

Government stocks of thorium nitrate in the National Defense Stockpile were 3,219,457 kilograms (7,097,687 pounds) on December 31, 1993. No stocks of thorium nitrate were sold or shipped in 1994. The stockpile's goal at yearend was 272,155 kilograms (600,000 pounds) of thorium nitrate. Stocks classified as excess to goal totaled 2,947,301 kilograms (6,497,687 pounds) and were all authorized for disposal.

The U.S. Department of Energy's inventory at yearend was 1,017,283 kilograms of thorium oxide equivalent contained in ore, metal, and various compounds.

Prices

The price range of Australian monazite (minimum 55% rare-earth oxide including thoria, f.o.b.)[1], as quoted in Australian dollars (A$)[2], remained unchanged at the previous years range of A$300-A$350 per ton. Changes in the United States-Australia foreign exchange rate in 1994, resulting from a weaker U.S. dollar on world markets, caused the U.S. dollar to be down $0.10 against the Australian dollar at yearend. The U.S. price range, converted from Australian dollars, increased significantly to US$233-US$272[3] per ton at yearend 1994, compared with US$204-US$238[4] per ton at yearend 1993. Prices for monazite remained depressed as several major world processors continued to accept only thorium-free rare-earth feed materials.

Thorium prices quoted by Reade Manufacturing Co., a division of Magnesium Elektron Inc., Lakehurst, NJ, at yearend 1994 were $330.76 per kilogram ($150.03 per pound) for thorium hardener (80%Mg-20%Th) in single drum quantities and $63.78 per kilogram ($28.03 per pound) for thorium-containing HZ-32 magnesium alloy ingot. The commercial magnesium—zinc-thorium alloy, ZH-62, was $47.91 per kilogram ($21.73 per pound).

World Review

Demand for thorium remained depressed as industrial consumers continued to be concerned with potential liabilities, the cost of compliance with environmental regulations, and decreases in the number of approved waste disposal sites.

Australia.—Tioxide Group Ltd. (TGL), a wholly owned subsidiary of ICI, divested itself of its 44.5% holdings in Westralian Sands Ltd. (WSL), a producer of heavy mineral sands, including monazite. The Japanese company, Ishihara Sangyo Kaisha Ltd. (ISK), also sold its 18.9% interest in WSL. Both TGL and ISK reportedly have long-term contracts with WSL for the purchase of minerals sands, but will concentrate investments in other areas. WSL reopened its Yoganup Extended mine in the first quarter of 1994 as markets for mineral sands improved. A new mineral sands concentrator was commissioned at the reopened mine in March to improve recovery rates.[5]

Minproc Holdings, a 50% owner in the Tiwest mineral sands joint venture at Cooljarloo, Western Australia, changed its name to Ticor Ltd. The joint venture, which includes Kerr-McGee Corp.'s (U.S.) Australian subsidiary, KMCC Western Australia Pty. Ltd., produced heavy mineral sands near Cataby and operated a dry separation plant and synthetic rutile plant at Chandala.[6]

Consolidated Rutile Ltd.'s (CRL), Gordon Mine on North Stradbroke Island suspended operation in March 1994 due to the sinking of its 3,000 metric ton per hour dredge. The dredge was refloated at midyear and resumed operation. CRL's other mineral sands operation, the Bayside Mine in Queensland, continued to operate. CRL noted it had ceased recovery of thorium-bearing monazite due to decreased world demand and problems in storing radioactive materials.[7]

Cable Sands announced the opening of the Jangardup minerals sands operation in Western Australia. The operation, located 60 kilometers south of Nannup in southern Western Australia, has a capacity to produce 230,000 metric tons of heavy mineral sands per year.[8]

BHP continued to assess development of the Beenup mineral sands deposit. Located in the Scott River area of Western Australia, the Beenup deposit would likely be mined by BHP's subsidiary Mineral Deposits Ltd. (MDL). MDL presently operates three mines in New South Wales.[9]

Renison Consolidated Goldfields Limited (RGC) operated four mineral sands mines in 1994. Three mines were operated in Western Australia, the Eneabba West, Eneabba North, and Capel. RGC's fourth mine produced mineral sands at Green Cove Springs, FL, in the United States. Except for the Eneabba North Mine operating at

75% of capacity, all other RGC mines reportedly operated at full capacity. RGC was a major world producer of monazite.[10]

France.—Rhône-Poulenc S.A. (RP) announced it had switched feed materials for its La Rochelle separation plant from monazite to a thorium-free intermediate compound, rare-earth chloride. Thorium waste generated during processing for the rare earths was previously sent for disposal to a French Government approved site in northern France until 1991. A 3 year extension of disposal privileges was allowed at a temporary storage facility through 1994.[11]

Malaysia.—Malaysian Rare Earth Corporation Sdn. Bhd.'s rare-earth plant at Ipoh, Perak State, announced it would close because of strong world competition, mainly from China. The plant had been closed because of public concerns over disposal of thorium waste generated during processing of the rare earths. The joint-venture operation was 35% owned by Mitsubishi Chemical Industries Ltd. of Japan.[12] *(See tables 2 and 3.)*

Outlook

Nonenergy uses for thorium in the United States have decreased substantially over the past 5 years. Domestic demand is forecast to remain at depressed levels unless low-cost technology is developed to dispose of residues. Industry manufacturers have been successful in developing acceptable substitutes for thorium-containing incandescent lamp mantles, carbon arc lights, paint and coating evaporation materials, magnesium alloys, ceramics, and investment molds. The traditionally small markets for thorium compounds, carbon arc lighting and welding electrodes, are expected to remain the leading consumers of thorium compounds. Thorium's potential for growth in nonenergy applications is limited by its natural radioactivity. Its greatest potential exists in energy applications, as a nuclear fuel or subatomic fuel, in an industry that accepts radioactivity. High disposal costs, increasing regulations, and public concerns related to thorium's natural radioactivity are expected to continue to negatively impact its future use.

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[1] Free-on-board.

[2] Metal Bulletin (London). Non-ferrous ores. No. 7942, Fri, Dec. 30, 1994, p.25.

[3] Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.2878=US$1.00 based on yearend 1994 foreign exchange rates reported in the Wall Street Journal.

[4] Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.4725=US$1.00 based on yearend 1993 foreign exchange rates reported in the Wall Street Journal.

[5] Westralian Sands Limited. 1994 Annual Report.

[6] Personal communication with A. Barry Brandt, vice president of investor relations and communications, Kerr-McGee Corp.

[7] Personal communication with Consolidated Rutile Ltd. company representative.

[8] Mining Journal (London). Jangardup Opened. V. 323, No. 8285, July 22, 1994, p. 59.

[9] Industrial Minerals (London). Scott River Mineral Sands Interests. No. 265, Oct. 1994, p. 12.

[10] Renison Goldfields Consolidated Limited. 1994 Annual Report. 47 pp.

[11] Industrial Minerals (London). RP Switches Rare Earth Ore. No. 319, Apr. 1994, pp. 15-16.

[12] Mining Journal (London). Malaysian Rare Earth Plant to Close. V. 322, No. 8262, Feb. 11, 1994, p. 106.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Bureau of Mines Annual Mineral Industry Surveys.
Bureau of Mines Annual Reports.
Bureau of Mines Information Circulars.
Bureau of Mines Minerals Yearbook.
Bureau of Mines Mineral Facts and Problems.

TABLE 1
SALIENT U.S. REFINED THORIUM STATISTICS 1/

(Kilograms of thorium dioxide, unless otherwise specified)

	1990	1991	1992	1993	1994
Exports:					
Compounds	220	2,650	93	189	7
Imports:					
Thorium ore metal, excluding monazite	189,000	205,000	187,000	--	--
Compounds	18,600	42,600	13,500	18,300	3,150
Shipments from Government stockpile excesses	2,170	--	--	--	--
Consumption, reported nonenergy applications 2/	65,500	54,300	40,400	12,800	17,300
Prices, yearend, dollars per kilogram, thorium dioxide equivalent: 3/					
Nitrate, mantle-grade	$16.55	$19.94	$21.36	$22.25	$23.30
Oxide, 99%-grade	$55.00	$63.80	$63.80	$65.00	$63.80

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ All domestically consumed thorium was derived from imported metals, alloys, and compounds; monazite containing thorium has been imported but has not recently been used to produce thorium products.

3/ Source: Rhône-Poulenc Basic Chemicals Co.

TABLE 2
U.S. FOREIGN TRADE IN THORIUM AND THORIUM-BEARING MATERIALS 1/

(Kilograms, unless otherwise specified)

	1993		1994		Principal destinations,
	Quantity	Value	Quantity	Value	sources, and quantities, 1994
EXPORTS					
Thorium ore, monazite concentrate	W	W	33,000	$21,100	Mexico 33,000.
Compounds	189	$68,100	7	12,600	Algeria 3; United Kingdom 2; Spain 1.
IMPORTS					
Compounds	18,300	479,000	3,150	140,000	France 3,120.

W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 3
MONAZITE CONCENTRATE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country 3/	1990	1991	1992	1993	1994 e/
Australia e/	11,000	7,000	6,000 r/	16,000 r/	6,000
Brazil	1,660	1,310	1,400	1,400 e/	1,400
China	2,380	1,190	1,800 e/	1,800 e/	1,800
India e/	4,500	4,000	4,000	4,600	4,600
Malaysia	3,320	1,980	777	407 r/	425 4/
South Africa, Republic of e/	1,320 4/	1,300	1,300	1,300	1,300
Sri Lanka e/	200	200	200	200	200
Thailand	377	400 e/	89	220 r/	200
United States	W	W	W	W	W
Zaire e/	124 4/	120	50	50	60
Total	24,900	17,500	15,600 r/	26,000 r/	16,000

e/ Estimated. r/Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 23, 1995.

3/ In addition to the countries listed, Indonesia, North Korea, Republic of Korea, Nigeria, and the former U.S.S. R. may produce monazite, but output, if any, is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels.

4/ Reported figure.

TIN

By James F. Carlin, Jr.

There was no domestic mine production of tin in 1994. Twenty-five firms consumed about 86% of the primary tin used domestically. The major uses were as follows: cans and containers, 32%; electrical, 22%; transportation, 11%; construction, 10%; and other, 25%. The estimated value of primary metal consumed in 1994 was about $270 million.

About 10,900 metric tons of purchased old and new tin scrap, including tin alloys, was recycled in 1994. Of this, about 6,900 tons was old scrap. About one-fifth of the tin consumed in the United States was produced from old scrap at detinning plants and 119 secondary nonferrous metal processing plants. There was continued interest in the recycling of used tin cans, largely owing to the rising costs and limited space of landfills. The recycling rate for steel cans was 53% in 1994, having risen from 40% in 1993 and 15% in 1988. In 1994, 11,360 tons of pig tin was sold from the National Defense Stockpile (NDS) leaving 136,559 tons in inventory at yearend, all of which was considered to be in excess.

World tin mine output in 1994 remained essentially the same as in the prior 2 years, the result of concerted producer efforts to restrict production. Nevertheless, there was an excess of tin on the world market for the 13th consecutive year. Excess stocks were believed to be about 35,000 tons at yearend.

The price of tin rose about 20% throughout the year. The price rise was attributed generally to increased consumption and some success by major tin producing countries in curtailing or leveling output.

Tin was mined in 28 countries in 1994, of which the top 5 accounted for about three-fourths of the world total of 183,000 tons. China was the largest producer with 27% of the world total, followed by Indonesia (19%), Brazil (15%), Bolivia (9%), and Peru (8%).

World tin reserves were estimated at 7 million tons and were considered adequate to meet the world's tin requirements in the near future. The bulk of these tin reserves were in Asia and South America.

Legislation and Government Programs

The NDS continued in its fifth year of being managed by the Department of Defense, with day-to-day operations guided by the Defense Logistics Agency (DLA).

The DLA sold 11,360 metric tons of tin from the stockpile in 1994. The bulk of the sales, 5,740 tons, were handled through long-term sales contracts to firms such as Considar Corp. (New York, NY), American Iron and Metal Corp. (Quebec, Canada), and M. C. Canfield and Sons Co. (Union, NJ). Also, direct sales were held each day, with orders for lots of 5 tons or more being accepted daily between 1:30 P.M. and 3:30 P.M. at the price set by DLA for that day.

Production

Mine Production.—For the first time in many years, there was no domestic tin mine production. In recent years, the Cache Creek Mine, in the Tofty District near Manley Hot Springs, AK, was the only mine in the United States to produce significant amounts of tin concentrates. The tin was recovered as a byproduct of gold mining. The mine, owned by Shoreham Resources, Inc., Houston, TX, in prior years, was sold to Cassiterite Placers Inc., Fairbanks, AK, in 1994 and was in its fourth year of production. The tin output from the mine had amounted to only a small fraction of domestic tin requirements.

Smelter Production.—For several years, there has been no domestic primary tin smelter. Any domestic tin mine output has been shipped to foreign smelters.

Secondary Production.—The United States was believed to be the world's largest producer of secondary tin. Tin metal recovered from new tinplate scrap and from used tin cans was the only type of secondary tin available in the marketplace as free tin; other secondary tin was available in scrap materials as an alloying ingredient. Secondary tin from recycled fabricated parts was used in many kinds of products and was a major source of material, particularly for the solder, and the brass and bronze industries.

The former Steel Can Recycling Institute (SCRI) that had been funded by five domestic tinplate producers to advance the collection, preparation, and transportation of steel can scrap in 1988, was in its first full year of expanded activities under a new name, the Steel Recycling Institute (SRI). The SRI now fosters the collection of all steel scrap (ranging from appliances to cars), not just steel cans. The SRI continued to maintain a program of having representatives in various regions of the United States work with municipalities, scrap dealers, and detinners to promote the recycling of tin cans.

The SRI made several announcements during 1994:

a) In the 6 years of SRI's existence, the recycling rate for steel cans has more than tripled, from 15% in 1988 to 53% in 1994. More than 18 billion steel cans, weighing 1.55 million tons, were recycled in 1994.
b) The SRI's goal is to achieve a 66% recycling rate for steel cans by the end of 1995.
c) The average American uses 144 steel cans each year. If every American recycles at least 95 steel cans in 1995, the goal of a 66% steel can recycling rate will be achieved easily.
d) Each year more than 30 billion steel cans are produced, packaging a variety of products from food and beverage, to paints, chemicals and personal care products.
e) Nine out of 10 aerosol cans are made of steel and are recyclable when empty. More than 1,700 communities across the country currently recycle aerosol cans.
f) More than 170 million Americans have convenient access to steel can recycling through curbside, drop-off, and buyback programs, as well as through magnetic separation at resource recovery facilities.

SRI continued to actively sponsor the

recycling of aerosol steel cans. It particularly pointed out its success in Michigan where a Statewide environmental campaign, sponsored and supported by a coalition of Government, industry, academic, and environmental leaders was encouraging Michigan consumers to recycle empty aerosol cans with other steel cans.

SRI also announced progress in its efforts to encourage many iron foundries to utilize scrap steel cans as part of their raw material charge. Iron foundries are found in virtually all 50 States, and they depend on steel scrap for about 50% of their charge material. Over the past 2 years, a small but growing number of foundries have been experimenting with melting used steel cans. SRI stated that nine foundries, all east of the Mississippi River, were accepting used steel cans. The attraction to foundries of using steel cans scrap is its low cost, consistent composition, and relative cleanliness. The downside to this scrap source is that the tin on the can surface has often been perceived as an unacceptable contaminant that could cause loss of strength and embrittlement in cast iron products. Among the first iron foundries to experiment with used tin can usage has been the Waupaca Foundry, Waupaca, WI; the U.S. Foundry, Medley FL; and the Intermet Corp., Lynchburg, VA.

One of the major domestic detinners, Proler International Corp., announced plans to expand capacity at its Coolidge, AZ, facility to recycle tin-bearing solutions from the electronics industry. Proler announced that the company had developed its own process to extract tin from solutions and sludges by adapting detinning technology used internally. Proler produced tin anodes from these solutions and sludges, which it sold back to the electronics industry. Proler felt the need to expand because demand for the service exceeded capacity at its existing plant. Arizona is the home of numerous electronics plants.

Consumption

Primary tin consumption remained about the same as in 1993 and other recent years. The demand pattern was similar to that of 1993.

Tinplated steel and tin-free steel accounted for 24% of the 139 billion cans shipped domestically; aluminum accounted for 76%. This compared with 1993 figures showing steel accounting for 26% of the 132 billion cans shipped domestically and aluminum accounting for 74%. Aluminum held an overwhelming advantage in the beverage can market, while steel dominated in the food can and the "general-line" markets.[1]

Bev-Pak Inc., Des Plaines, IL, with production facilities in Monticello, IN, completed the transfer of all of its three beverage can production lines to aluminum, thereby eliminating its status as a steel or tinplate purchaser and as a major producer of steel cans. The company started in the late 1980's and immediately forged for itself a special niche as a producer of steel cans. Bev-Pak had claimed about 50% of the domestic steel beverage can market and a 2% share of the total U.S. beverage can market. The domestic beverage can market has been increasingly dominated by aluminum during the past 30 years. The firm attributed the switch in materials to recently lowered prices for aluminum can sheet and to the end of its contracts with Coca-Cola, Pepsi Cola, and 7-Up, which had desired steel cans for certain steel-producing Midwestern States. Industry sources felt the switch by Bev-Pak represented about a 1% slice of the 4-million-ton-per-year tin mill products market. Crown Cork & Seal Co., Philadelphia, PA, still operated two steel can production lines that could be switched between aluminum and steel feedstocks.

U.S. Can Corp., Oak Brook, IL, completed purchase of Baltimore, MD—based Steeltin Can Corp. and two affiliated firms. Steeltin is a regional producer of containers for the specialty food and paint markets.

In the spring, Weirton Steel Corp., Weirton, WV, one of the largest domestic tinplate producers and therefore one of the largest domestic tin consumers, suffered major fire damage to its No. 9 tandem cold-rolling mill. The cold-rolling mill, one of the key process units preparatory to the steel coil entering the tin mill, had an annual capacity of about 900,000 tons. Weirton moved as much light-gauge sheet production as possible to two other tandem mills. The outage continued into the fall, with Weirton having partial success arranging interim tolling arrangements with other tinplate producers to meet its customers' needs. About 40% of Weirton's shipments is tin mill products. Of all domestic tinplate producers, Weirton's total steel output has the heaviest weighting toward tinplate products.

One of the domestic tinplate producers, Wheeling-Pittsburgh Steel Corp. Wheeling, WV, announced plans to construct a new joint-venture tinplate mill in Belmont County, OH. Construction was set to begin in early 1995, with completion planned for late 1996. The tin mill is a joint venture of Wheeling-Pittsburgh Steel Corp., Dong Yang Tinplate Industries Co. Ltd., South Korea, and Nittetsu Shoji Inc., Los Angeles, CA. Wheeling-Pittsburgh and the United Steelworkers of America reportedly reached an agreement in principle concerning all employment issues for the $80 million mill. The mill is expected to use about 500 tons of tin per year. It would be the first tinplating facility constructed in the United States since the early 1960's, and would replace Wheeling's current 50-year-old tin mill. Upon announcement of the project, the State of Ohio became active in assisting the venture, obtaining a 10-year tax abatement for the mill and working with the county in seeking government grants for equipment and employee training. Tinplate represents about 9% of Wheeling's output. (See tables 2, 3, and 4).

The American Iron & Steel Institute's (AISI) Steel Packaging Council, formerly the market development arm of AISI's Tin Mill Products Committee, commenced a 5-year, $12.5 million program to promote the nutritional value and convenience of canned foods. The Council expressed concern that over the past 10 years, while the domestic population has been growing, canned food shipments have been flat. The intent was to help forge a modern image for canned food and thereby boost tin mill shipments to can makers.

Prices

The price of tin metal, as published in Platt's Metals Week, generally rose throughout the year, with the sharpest increases coming in the final 2 months. The price at yearend was about 20% higher than at the beginning of the year. Analysts believed the strong price action in 1994 was due to improved world demand and to some select successes by large tin producing countries in restricting their output or exports.

The London Metal Exchange (LME)

remained the primary trading arena for tin. Tin was one of only six metals (along with aluminum, copper, lead, nickel, and zinc) to be traded on the LME. The Kuala Lumpur Commodities Exchange in Malaysia continued as an active tin trading forum.

Foreign Trade

The marketing of tin metal in the United States was performed mostly through trading firms, which imported the tin from a variety of countries and warehoused it in this country until they sold it to customers. Foreign-owned trading firms tended to dominate the field. Most tin dealers were based in the New York, NY, area. Some tin also was marketed directly in the United States by large foreign producers who maintained sales offices here and sold their tin metal, usually on a 1-year contract basis, only to the largest users. Perhaps foremost among these direct-sale operations was Indo-Metal Corp., which served as the exclusive North American sales outlet for tin metal produced by Indonesia's Government-owned tin production organization, P.T. Tambang Timah.

For the third consecutive year, Brazil was the major source of U.S. tin metal imports. Bolivia ranked second, followed by Indonesia, China, and Malaysia. Imports, which supply the majority of domestic tin requirements, remained about the same as in 1993.

Imports of tin in all forms (ore and concentrate, metal, waste, and scrap) remained free of U.S. duty. (See tables 5, 6, and 7.)

World Review

At the Association of Tin Producing Countries' (ATPC) Annual Meeting of Ministers in Bangkok, Thailand, on September 19 and 20, several important events occurred:

a) It was agreed in principle that Brazil, the world's third largest tin producer, would become an ATPC member. Brazil's inclusion in the ATPC would increase the share of tin supply under the aegis of the producer group from 66% to 82% of the world total.

b) China, the world's largest tin producer, pledged to hold its 1995 export quotas at 1994 levels.

c) The ATPC decided to extend the Supply Rationalization Scheme (SRS) into 1995, with a 7.55% cutback from 1994's SRS. Total permissible export tonnages for ATPC members in 1995 are:

Australia	7,800 tons
Bolivia	16,600 tons
China	20,000 tons
Indonesia	30,000 tons
Malaysia	8,200 tons
Nigeria	1,900 tons
Thailand	4,500 tons
Zaire	1,100 tons

d) The ATPC estimated current tin excess stocks to be on the order of 40,000 tons. It expected member country stocks to reduce by about 5,000 tons by yearend. The ultimate goal remained to reduce stocks below 25,000 tons.

Australia.—Renison Consolidated Goldfields Ltd. remained the major tin producer in the country. Renison operates the Renison Bell tin mine at Zeehan, Tasmania. In recent years, the company has achieved considerable cost reduction at Renison Bell. Productivity reportedly has increased 40% over the past 3 years.

Reportedly the Renison Bell tin mine now ranks among the lowest cost third of all world tin producers. Exploration of the mine's Rendeep section, started in recent years, has been an important facet for the mine. The Rendeep area, which is about 600 to 800 meters below the surface at the northern end of the mine, has been shown to contain significant reserves of high grade tin ore, sufficient to extend mine life by at least 6 years.

Exploration to date of the Rendeep resource has delineated a probable reserve of 3.3 million tons grading 1.96% tin with additional resources of 3 million tons at 1.5%. Metallurgical testwork has indicated higher recovery from Rendeep ore than from existing reserves. The firm is investing $30 million to sink a new hoisting shaft which would permit lower cost hoisting of Rendeep ore as well as that from the lower levels of current reserves. This should enable the mine to expand production to over 9,000 tons per year of tin-in-concentrate.

Bolivia.—The first steps toward the privatization of Bolivia's Government-owned COMIBOL mining organization began to take place. A delegation of Bolivian Government mining officials was due to be dispatched to London, England, to solicit interest among antimony, lead, tin, and zinc circles. On offer are exploration and mineral rights, mining operations, smelters, refineries, infrastructure, and equipment. To facilitate the process, COMIBOL would be reorganized into a company exclusively involved with the administration of lease and joint-venture contracts with the private sector for the nonprivatized assets. In order to make the offerings more attractive, the Ministry of Mines announced that all debts and most environmental liabilities would be assumed by the Government.

A number of pollution control measures have already been implemented at the smelters. For example, in 1993, the German firm Stolberg conducted a feasibility study into reducing pollution at the Vinto tin smelter. The project for environmental control now has financing from the German Government for about $6 million.

A process of rationalization has been undertaken over the past 3 years that eases the move to privatization. Only three COMIBOL tin mines are now operating: Huanuni, Caracoles, and Colquiri. All money-losing operations have been closed. Also, COMIBOL had reduced its work force from 28,000 in 1984 to 1,500 in 1994.

As a result of the planned privatization, tin, lead, and zinc production are expected to grow significantly. Tin output in 1993 and 1994 was in the 16,000 to 19,000 ton range. Of that amount, an estimated 4,000 tons was toll-smelted for the San Rafael tin mine in Peru. Output for 1995 was anticipated to rise to 20,000 tons, of which 10,000 tons would be toll smelted for San Rafael.

Brazil.—The country's major tin producer, Paranapanema SA, embarked on a program to reduce its output of tin concentrates by about 50% in 1994, so as to be consistent with objectives set by the ATPC at its meeting in October 1993. Paranapanema was expecting to produce about 7,000 tons of tin-in-concentrate, down from 13,000 tons in 1993. In worldwide terms, this reduction represents about 4% of primary tin output. In addition to its directly owned assets, including the high grade Pitinga Mine, the company also holds a 52% stake in Empresa Brasileira de Estanho SA (EBESA) which holds the mining rights for the Bom Futuro tin mine in the Amazon region. Output at Bom Futuro was believed to have remained rather steady in 1994 at about 11,000 tons of tin-in-concentrate.

Mineracaõ Taboca, a wholly owned subsidiary of Paranapanema, won a bid to develop a tin mine in the State of São Paulo. Mineracaõ Taboca agreed to pay $1.1 million for the project plus royalties equivalent to 15% of the value of the ore extracted from the mine. The firm will pay $150,000 to conclude studies on the site, which is estimated to contain some 5,000 tons of tin ore reserves at an average grade of 1.5%. These studies were expected to be concluded by early 1995, and if favorable, mine development could start in late 1995. While of modest size, the deposit is considered to be of strategic interest since it is only 483 kilometers (300 miles) from the city of Saõ Paulo, where the large Mamore tin smelter is located.

Cesbra, Brazil's second largest tin smelter, and Minsur, the parent organization of the San Raphael tin mine in Peru, terminated its long-term tolling contract. Under this contract 8,000 to 11,000 tons of tin concentrates were smelted each year at Cesbra's tin smelter near Rio de Janeiro. The loss of this contract was expected to affect Cesbra seriously. As a result, Cesbra was forced to layoff over 100 workers at the Volta Redonda tin smelter, thereby reducing the work force to only 160. The tolling contract had been in effect since 1991. Reportedly, Minsur had sought major reductions in treatment charges, which Cesbra was unwilling to meet. Minsur's mine output is now being shipped to tin smelters in Bolivia, Malaysia, Russia, and Thailand. The loss means Cesbra's smelter output is now only 200 tons per month of tin metal, all from Brazilian concentrates. This represented about one-fifth of the smelters' installed capacity of 1,000 tons per month. Cesbra exported 60% of its output, with the balance sold to a domestic steelmaker or to local tin solder producers.

SNA Minerios a Metais Ltda., a small tin smelter, shut down after a shortage of tin ore had reduced its smelting operations to just 20% of the facility's 500-ton annual capacity. As part of the closure, SNA laid off about 50 workers and sold its 5.4% share in Ebesa, the tin consortium that buys two-thirds of the tin ore extracted from the Bom Futuro Mine in western Rondônia State. Paranapanema purchased 75% of SNA's Ebesa stake, with Companhia Estanifera do Brasil taking the remainder. SNA's management said operations would be resumed only if it finds enough tin ore to smelt at 50% of the firm's installed capacity. Until the closure, SNA produced tin with a purity ranging from 99.95% to 99.98%, most of which was sold to consumers in Europe. SNA's tin concentrates had originated mostly from Mineracaõ Canopus which has a mine in northern Para State, and from its stake in Ebesa. Problems developed for SNA this past year when a drop in ore output at Mineracaõ Canopus and Bom Futuro caused a major reduction in the company's tin ore supply. Canopus, which itself smelted 1,200 tons of tin in 1991, reduced its own smelting output to a level of 480 tons per year starting in September 1993. The Bom Futuro Mine provided Ebesa with only 1,600 tons of tin-in-concentrate in the first 3 months of 1994. Ebesa had expected to receive 2,400 tons.

The São Paulo provincial government called for tenders to exploit tin deposits at a site in the south of the State. Initial surveys indicated about 5,000 tons of tin available in a combined cassiterite/wolframite deposit, grading up to 1.5% tin. There would need to be additional surveys, and it would be at least 2 years before a mine could start commercial production. A bid for the site was made by Mineracaõ Tobaca, a mining subsidiary of Paranapanema.

Burma.—The State-operated No. 2 Mining Enterprise (Myanmar) and Thailand's Roong Siam Mining Co. signed a production sharing contract (PSC) for offshore tin exploration and exploitation off the Gulf of Martaban and off the coast of Tenassarim. The contract block included the Heinze Basin, an area with known tin deposits. Since early 1990, Myanmar had signed three similar PSC's with three different Thai mining firms but none of these prior three efforts resulted in any tin production.

Canada.—Major steelmaker Stelco, Inc., was reportedly considering ending production of tinplate. If its considerations were actualized, Stelco's tinplate production could cease in 1995. Stelco had been moving away from tinplate production for some time. In 1994, it operated one tin mill at its Hamilton, ON, steel plant producing tinplate, Tin-Free-Steel (TFS), and blackplate. The company, formerly called Steel Company of Canada, has produced tinplate since the late 1940's and there are indications the firm may concentrate on alternative areas of business rather than spend considerable funds to upgrade its tin mill. Stelco's tinplate capacity is about 350,000 tons per year, but production has been only about 200,000 tons per year in recent years. This is despite the fact that Canada has not experienced as marked a shift away from steel beverage cans toward aluminum beverage cans as has the United States over the past 30 years. If Stelco should cease tinplate production, Dofasco Inc., would remain as Canada's sole tinplate producer.

China.—China formally joined the ATPC for the first time in April, but its membership did not come into effect fully until June. Previously, China had an unofficial "observer" status in the ATPC. It has agreed to meet a 1994 export quota of 20,000 tons but in the first quarter alone it exported nearly 10,000 tons. Chinese officials reportedly blamed the excess shipments on a loss of control over exports after reforming the foreign trade system. They indicated that they have since issued new rules which will regulate exports and help to meet the requirements of the ATPC.

France.—One of the world's largest can makers and tinplate users, Carnaud-Metalbox (CMB), reported gains in many of its activities. The firm resulted from the merger, a few years ago, of two of the largest European can-makers: Metal Box (the United Kingdom) and Carnaud (France). About 80% of the firm's business is in Europe, but it employs 32,000 people in 173 plants in 34 countries. Annual sales are about $4 billion. Recently, CMB acquired the Finnish metal packaging firm, Sohlberg. In recent years, CMB has made major investments in new can plants in Asia. Profits have reportedly been hampered over the past 2 years by recession in Germany and Spain.

Germany.—Germany's major tinplate producer, Rasselstein, joined several other large European tinplate producers in a joint-worldwide effort to promote the use of tinplate. The other tinplate producers are: Sollac (France), British Steel (UK), and Hoogovens (The Netherlands). The project was expected to be officially starting in early 1995 and would feature a Brussels-based marketing team comprising staff from all four firms.

Later in the year, Rasselstein announced that tinplate now controls 85% of the German can market, which the firm attributed partly to its timely introduction of the 2-piece can.

The company further stated that European tinplate makers were on the leading edge of "lightweighting" their can stock to ward off competition from aluminum. In the conservation area, Rasselstein noted that the German tin can industry had achieved a 50% reduction in material consumption since 1970, reduced energy use by 70%, and had achieved a 48% recycling rate.

Metallgesellschaft announced the closure of its last tin smelter. The firm closed the Duisburg tin smelter, part of its Berzelius Stolberg and Hüttenwerke Templehof Division, due to low tin prices that caused the smelter to be unprofitable. The smelter produced high-grade tin-based solders in the form of bars, sticks, foils, and wires. The smelter had the capacity to produce 10,000 tons of material yearly, although it recently produced at the rate of about 3,000 tons per year.

Indonesia.—The country maintained its position as the world's second largest tin producer from mine sources and the third largest producer of smelted tin metal. The country's main tin producer, Government-owned P.T. Tambang Timah announced plans to go public in 1995. Up to 20% of the firm's shares would be sold, and the funds generated would be used to upgrade the dredges and for a training program to improve the skills of its labor force. The organization produced an estimated 80% of Indonesia's tin output and exported almost 31,500 tons of tin in 1994. It sought to increase the tin production quota for 1995 to 36,000 tons. At current production levels, Timah estimated its commercial tin reserves would last more than 25 years.

The other major tin producer in Indonesia, P.T. Koba Tin, announced plans to increase tin concentrate production in 1996. Koba planned to place a new dredge into operation that would increase its capacity from 7,500 to 10,000 tons per year.

Malaysia.—Just a decade ago the world's dominant tin producer, Malaysia's tin industry activity continued to decline. Malaysian tin mine production in 1994 was about 40% lower than in 1993. Government officials indicated that 30 tin mining operations closed during the year, leaving only 76 operations active.

Netherlands.—Billiton Nederland BV announced that it had completed an agreement with the Cookson Group PLC (UK) to sell Billiton's tin/lead solder making subsidiary, Billiton Witmetaal, to Cookson. Witmetaal, with annual sales of about $30 million, has facilities in Naarden (The Netherlands), Nuremburg (Germany), Antwerp (Belgium), and Paris (France). Witmetaal was to be merged into Cookson's Alpha-Fry Group, which Cookson formed in 1993 when it reorganized its solder operations by merging its Fry's Metals subsidiary (mostly a producer of industrial solders) with its Alpha Metals subsidiary (mostly a producer of electronic solders). Cookson announced that Witmetaal would be increasing its capacity from 7,000 tons of solder annually to 8,500 tons annually in 1995, of which 55% would be industrial solders and 45% would be electronic solders. Billiton had recently been sold by parent Royal Dutch Shell Corp. to Gencor (South Africa). Cookson, which is the world's major solder-maker, with several units in the United States, announced it would be focusing its marketing strategies upon Eastern Europe, and would be gearing up for the expected increase in demand for electronic products from the Commonwealth of Independent States, the Czech Republic, and the Republic of Poland.

Hoogovens was the Netherland's largest steel producer and one of the major tinplate suppliers in Europe. It also had a substantial detinning subsidiary, Hoogovens Scrap Processing (HSP). HSP operated six detinning plants in Belgium, Denmark, Germany, the Netherlands, and Switzerland.

The company had registered some setbacks recently and had been affected by what it viewed as a substantial increase in demand for tinplate scrap by Europe's steelmakers. At midyear, HSP was forced to close its 25,000-ton-per-year detinning plant in Strib, Denmark, because of stringent noise abatement laws. In 1993, its detinning plant in Burgdorf, Germany, was idled by a lack of feedstock. HSP attributed the shortage of scrap tinplate in its market to the growing practice of some European steelmakers, especially in Germany, of charging furnaces directly with scrap tinplate. HSP has a processing capacity of 200,000 tons of scrap tinplate yearly, but is currently processing only at the 135,000-ton-per-year level.

Peru.—This country continued its remarkable surge in tin mine production, which has carried it to fifth place among major world tin producing countries. Over the past 5 years, Peru has almost tripled its annual tin mine output. Peru's only tin producer is privately owned Mineras Sur (Minsur) SA. Minsur operates the San Raphael tin mine in the southern department of Puno. Presently, tin concentrates are exported for smelting, mostly to Bolivia and Brazil. But Minsur's wholly owned subsidiary, Finsur, was formulating plans early in 1994 to construct a 16,000-ton-per-year capacity smelter on the coast of Peru, at Pisco, 290 kilometers (180 miles) south of Lima. By midyear, it was reported that Minsur had signed a contract with Australia's Ausmelt Ltd. to utilize its technology in the new tin smelting plant. It was expected that the refinery would take 2 years to construct and would have an initial capacity of 30,000 tons annually of tin-in-concentrate. Late in the year it was announced that Minsur signed a contract with The Ministry of Mines and Energy, under which Minsur would receive $35 million for the construction of the new tin smelter and expansion of mine capacity.

The San Rafael tin mine has operated since the 1950's. It is a large conventional underground mine high in the Andes at an altitude of some 5,000 meters. It is accessed via a ramp and uses trackless mining equipment. Proven and probable reserves reportedly are about 2 million tons grading 3.2% tin and 0.85% copper.

In view of Peru's substantial and increasing tin production, the question of its eventual membership in the ATPC has been raised. Peru's Minister of Energy and Mines recently stated that if it appeared that the country's increased tin output was affecting the world market, Government officials would work with Minsur to consider an ATPC membership.

Philippines.—The National Steel Corp. (NSC) of the Philippines announced that it expected to produce 156,000 tons of tinplate in 1994 compared with 106,000 tons in 1993. In 1992, the company had added a 150,000 ton-per-year tinplating line at its Illigan works. NSC also has two tinplating lines with a combined capacity of 150,000 tons annually at its older Manila plant. It stated that the weak Philippine economy and cheaper tinplate exports from countries such as the CIS have prevented NSC from producing at full capacity. The Manila plant also was affected in 1993 and 1994 by power shortages. Only one tinning line is used at the Manila plant; the 60,000 ton-per-year line is shut down temporarily. In 1994, NSC planned to produce 90,000 tons of tinplate on its newer line and 66,000 tons on the Manila line. Black plate is sourced from NSC's own mills, with supplements from Japan, Korea, and Taiwan. The firm exported about 25% of its tinplate to southeast Asia.

Portugal.—The country has experienced marked growth in its tin mine production in recent years. Production has almost tripled in the past 5 years. The source of Portugal's tin is the Neves Corvo copper-tin mine, which is owned by Sociedade Mineira de Neves Corvo SARL. Neves Corvo, in southern Portugal, is Europe's largest tin mine. Somincor has invested considerable funds in recent years at Neves Corvo, especially in improving tin concentrate grades. These improvements were associated with Somincor's long-term contract with the Zamora tin smelter in Spain, which has traditionally been a processor of high-grade tin concentrates. Somincor attributed the increase in 1994 tin mine output to these investments and also to the striking of a higher tin ore grade early in the year. Not all of Neves Corvo's tin concentrate output goes to Zamora; some also is shipped to the two large Malaysian tin smelters.

Russia.—Over the past 2 years, eight tin mines were forced to close in Russia, leaving the country with only four operating tin mines. To prevent the situation from worsening, the tin industry in Russia reportedly began discussions to forge stronger links and possibly even unite into a single financial/industrial group called Russia Tin. At one meeting of interested parties in Novosibirsk, the location of the country's largest tin smelter, mine officials were informed that the smelter sought to increase cooperation with the tin mines. Smelter spokespeople stated that the smelter was no longer willing to rely mostly on treating imported concentrates. It was observed that the cost of domestic tin concentrates has often been more than that of imported concentrates and that inefficiencies, poor equipment, transport problems, and lack of investment have severely hindered most of the Russian tin mining industry. The meeting included managers from Deputatsky, Solnechny, the Khingalovo mining and enrichment complex, the Khrustalnenskaya tin mining company, and Kyztsvermet; these officials pointed to high taxes, high energy costs, and high freight costs as especially burdensome.

South Africa, Republic of.—ISCOR Ltd., the major steel producer and tinplate maker in the country reportedly began constructing a new tinplating line. Scheduled to open by mid-1995, the line would add a further 130,000 to 180,000 tons annually to capacity. Capacity had been 350,000 tons yearly. To achieve this, ISCOR was converting an existing tin-free steel line to tinplate production at a cost of $10 million. ISCOR based its planning on reports of a 10%-plus increase in the domestic beverage can market by 1998-99, which would take demand in that sector to 315,000 tons of tinplate annually. The firm's aim was to obviate the need for tinplate imports and to cover all domestic demand itself with some left over to export.

Thailand.—This country rated as one of the world's top tin producers during the 1980's, but reports continued to indicate declining tin mine production. One official stated that Thailand could even become a net tin importer in the next few years. Continuing industrialization of the country has boosted domestic tin demand. Over the last 10 years, the number of active tin mines in Thailand reportedly has declined from about 500 to less than 30. If net exports do actually decline, and Thailand becomes a net importer, the country could be obliged to give up its ATPC membership.

A speaker representing The Thailand Smelting and Refining Co., the major tin smelter in Thailand, at Metal Bulletin's 3rd International Tin Conference in Jakarta, Indonesia, offered a summary of recent developments in the Thai tin mining-smelting-consumption industries. For more than 100 years, Thai tin concentrates have been produced in the region of Phuket and along the western tin belt. Production reached a peak of 35,000 tons of tin-in-concentrate in 1980, with offshore dredges contributing over one-half of that total. The speaker enumerated four factors contributing to the current low production:

a) Depressed tin price led to the closure of several tin mines .
b) High-grade and easy-to-mine tin deposits are mostly depleted.
c) The mining sector is losing out to the rising tourist industry in the competition for land.
d) Environmental protection, partly to benefit tourism, is now an obstacle.

However, he illustrated the growing domestic tin consumption. The Thai canned food industry, especially, is increased rapidly, creating demand for local tinplate. Thai solder consumption is growing 10% annually due to rapid growth in the domestic electronics industry.

Thailand's Council of Economic Ministers agreed to transform the money-losing Offshore Mining Organization (OMO) into a joint-venture company with private firms. The new venture would absorb $8 million in assets and $5 million in liabilities and 170 employees. The joint-venture firms would also be given OMO's four existing blocks of offshore tin mining concessions and would be obliged to continue offshore tin mining using OMO's dredger and equipment.

United Kingdom.—The South Crofty Mine, the last operating tin mine, launched a $1.5 million share issue in an attempt to secure its immediate future during the summer. The British Government agreed to waive repayment of $35 million in loans made to the mine since 1985 provided that the $1.5 million share subscription was successful. South Crofty, in the Cornwall District, treated 180,000 tons of tin ore in 1993 to produce about 1,900 tons of tin-in-concentrate. All of the mine's tin concentrates were shipped to the Datuk Keramat Smelting Co. tin smelter in Malaysia. The mines' total identified reserves were 700,000 tons grading 1.48% tin, with further inferred reserves of 2.6 million tons grading 1.46% tin; working mine life was projected to be at least 10 years. The mine's Wheal Jane mill is considered one of the world's most efficient tin concentrators.

By the fall, new ownership had taken control of the South Crofty Mine. Bearing the new name South Crofty Holdings Ltd. (formerly known as Crew Natural Resources, based in Canada), the new owners sought to raise $3 million from investors through a private placement to fund improvements and expand production at the mine. The new owners pointed out that the firm was now debt-free and anticipated breaking even once expansion was completed. Reportedly, while the South Crofty tin mine had cut costs sharply, it was still operating at a loss of about $400 per ton, owing to the mining of lower grade ores and the inability to increase throughput. Immediate reequipping would cost only about $100,000, but if the firm wished to lower costs even more, one option would be to relocate the milling operation now at the Wheal Jane site; by moving it to South Crofty, the firm believed it could save about $500,000 annually in tin-in-concentrate transport costs. About $5 million reportedly would be needed for that option. The firm indicated that a decision would be needed in the next few years since the mine tailings dam at Wheal Jane would become obsolete in about 7 years; by then the firm must decide whether to move the mill or expand the dam. Other changes being considered at the Wheal Jane mill reportedly are removal of barren sand from the gravity circuit and the installation of a second multigravity separator to run in parallel with the existing one, thus improving throughput as well as recovery rates. South Crofty was also reportedly mulling the development of a toll-treating line for zinc ores and other ores.

South Crofty aimed to increase its mill recovery rates to the 87% to 90% level. The average grade of concentrates is now 58% tin, and metallurgical recoveries average 85%. At the mine, the Cook's Kitchen shaft is used for all ore and waste handling, material handling, and worker transport, while the Robinson shaft serves as an emergency exit. The mine is being developed by a combination of shaft and decline access, with two mining methods employed: shrinkage stoping and sublevel long-hole open stoping. During the period 1906-93, South Crofty treated 8.7 million tons of ore, recovering 68,000 tons of tin-in-concentrate. Current identified plus inferred reserves are estimates by management at 3.3 million tons, grading 1.5% tin, or about 50,000 tons of tin.

India's Solo Industries, which bought shares in the South Crofty public stock sale, started receiving South Crofty tin concentrates in the fall. Half of all Crofty production was slated to go to Solo's tin smelter near Bombay under a long-term contract; the remaining output would be divided between tin smelters in Malaysia and Indonesia.

Vietnam.—Domestic tin producers were reportedly demanding major Government relief from royalty and export taxes and threatened that all domestic tin mines might close unless such relief were granted. The Rare and Precious Minerals Corporation of the Vietnam Ministry of Heavy Industry indicated that domestic producers, including the Cao Bang Non-Ferrous Manufacturing Co., the Thai Nguyen Non-Ferrous Manufacturing Co., and the Nghe Tinh Non-Ferrous Manufacturing Co. have been losing substantial amounts of money in recent years due to low tin prices. Producers sought a 50% reduction in the tin royalty tax and a 20% reduction in the export tax.

Vietnam has shown an increasing trend of tin mine output over the past 5 years. The country has seven major tin-producing areas and estimated reserves of 85,000 tons of contained metal.

Current Research

The USBM Rolla Research Center in Missouri investigated characteristics of recycled automotive oil filters, many of which are fabricated from tinplate. Increasingly, over the past several years, used oil filters have become a steel scrap item used as an electric furnace scrap charge by steel mini-mills. TAMCO Steel Co., Rancho Cucamonga, CA, has been prominent in such scrap usage. USBM research showed that crushed and drained oil filters have a bulk density that is higher than many traditional scrap steel grades, a chemical analysis low in residual elements (except tin), and an overall yield of oil-filter scrap to cast steel of 76% to 85% depending on the method used to prepare the scrap.

The International Tin Research Institute (ITRI), based in Uxbridge, United Kingdom, the world's foremost laboratory for tin scientific research and new tin applications, completed a transformation in its structure late this year. The ITRI has now become privatized, with funding now supplied by several major tin producer firms rather than by the Association of Tin Producing Countries. The Institute is now called ITRI Ltd. Among the firms funding ITRI are Renison Goldfields Consolidated Ltd. of Australia; P.T. Timah and P.T. Koba Tin of Indonesia; Malaysia Mining Corp. of Malaysia; Minsur SA of Peru; and Somincor of Portugal. Disclosure of other participating producers, as well as membership by smelters and tin consumers, was to be made later. ITRI, in operation since the 1930's, is primarily a research organization that focuses its efforts on expanding the consumption of tin. Among the areas of current interest are lead-free, tin-rich solders; tin chemicals for fire retardants in polyvinyl chloride, plastics, and paper; and tin/zinc alloys for corrosion-resistant coatings.

One area that the ITRI has been focusing on in recent years has been in developing tin foil bottle capsules to replace lead foil. Protective top capsules are used for many wine and spirits bottles, which are applied as a printed closure around the cork or stopper area. This top capsule has a decorative and promotional function, but it also acts as extra protection for the cork against mold growth, and an extra barrier to oxygen ingress which could affect contents. In addition, it presents a tamper-evident seal, which is now considered critical in many forms of packaging, especially pharmaceticals, in view of the well-publicized criminal tampering cases of the past decade. The total worldwide consumption of such capsules is estimated at 8 billion units per year and they have utilized three main foil materials: lead/tin, aluminum, and PVC. The lead-based foil material has been the traditional material used for premium quality wines and spirits, with an estimated 2 billion units consumed in 1991. The lead capsule material consists of a thin foil of lead (about 95% to 98% by weight) coated on each side by a very thin layer of roll-bonded tin, which is to prevent contact between the lead and the bottle contents (as well as human fingers). In recent years, there has been increasing concern about possible contamination of wine by this lead capsule. This could be caused by corrosion promoted by direct contact with wine that has seeped through the cork. This could deposit lead salts around the lip of the bottle. Studies have concluded that the main lead contamination occurs when the wine is poured out of the bottle, after the capsule and cork are removed. Also, the disposal of the capsule adds another toxic heavy metal into the waste stream. The European Union banned lead capsules effective January 1, 1993. The great majority of these capsules were manufactured in Europe and used throughout the world. ITRI reported that the U.S. Food and Drug Administration has issued a proposal to ban the use of lead capsules. California, which reportedly produce over 80% of American wines, banned their use on January 1, 1992, and on any imported products March 31, 1993.

ITRI responded to the capsule challenge, believing a product based on tin was feasible for several reasons:

a) Tin foil has a similar soft feel to the touch and conveys a luxury or premium image, enhanced by its amenability to high quality printing.

b) The material could be used in existing capsule-forming and bottling equipment.

c) It can easily be removed manually from the bottle by tearing, without risk of cuts to the fingers.

d) It is nontoxic, and the waste material is also recyclable.

The ITRI reports that in the last 3 years, most of the major capsule producers have introduced tin capsules as a direct substitute for lead in the premium wine and spirits markets, which are now enjoying high growth in many parts of the world. ITRI continued research on reducing the weight of the tin capsule to make it more cost competitive with alternative materials. The weight of commercial tin capsules has been reduced now to 4.5 grams, compared with a figure of 10 grams for the original lead-based capsule. It is estimated that 5,000 tons of tin annually is now being used in this application worldwide.

The ITRI reported favorable developments on its work on a new noncyanide based electrolyte called "Stanzec." Its work involves an alloy of tin and zinc that could replace toxic cadmium as an environmentally friendly anti-corrosion coating on steel. "Stanzec" now has been patented for rack or barrel plating, and the plating process has been licensed to a major plating company. The process is currently being scaled up for commercialization in the United States. Reports indicate that tests on the 75% tin-25% zinc alloy coating have shown it to be markedly superior to zinc, cadmium, and zinc-nickel; and, unlike these other coatings, tin-zinc can be used without a chromate passivation film. Reportedly, some leading Japanese car makers have made tin-zinc plating a standard specification for certain car components. The alloy also was expected to fill applications in the aerospace and construction industries. ITRI also was attempting to develop a high-speed tin-zinc plating electrolyte for the continuous plating of steel strip.

In Japan, it was announced that lead-free solder for printed circuit boards, claimed to be the first of its kind in the world, had been developed jointly by Mitsui Mining and Smelting Co., Harima Chemicals Inc. (Osaka), and the Welding Research Institute of Osaka University. Researchers claim the newly developed lead-free solder is similar to the widely used tin-lead eutectic solder, which melts at 183°C, in a variety of standards such as tensile strength, elongation, and other mechanical and electrical properties. Researchers stated that the new solder was available in two varieties: one is a tin-silver type with a melting point of 210°C, and the other is a tin-zinc type with a melting point of 190°C. A spokesperson indicated that further studies will be conducted to apply the technology to producing lead-free flux-cored wire solder and solder paste.

In the United Kingdom, it was reported that the Hirst Research Center of GEC-Marconi Ltd., Wembley, performed developmental studies toward a new low temperature diffusion soldering process in which tin is used for joining carat gold jewelry. Diffusion soldering is a hybrid of diffusion bonding and soldering. The principle of the process is to run a minute volume of solder into a joint between components that are pressed together and to solidify the solder by conversion to high melting point phases through isothermal reaction with the substrates. Thereafter, the joint will not remelt unless heated to the temperature at which the high melting point phases melt. Tin was found to be suitable to make diffusion soldered joints between components of pure gold. The studies evaluated tin as a diffusion solder for joining items of 18 carat gold alloys representative of alloys widely used in the fabrication of jewelry. Joints can be made by heating to 450°C, which is substantially lower than the temperature needed for brazing of jewelry using conventional carat filler alloys. The resulting joints were found to be color matched and have mechanical properties that are likely to be adequate for jeweler applications.

It was reported that a stainless steel coated with a terne alloy was successfully utilized in a unique construction application. The roof of the new main terminal at Pittsburgh (PA) International Airport was designed and constructed with AISI type 304 stainless steel coated on each side with 20 micrometers of a terne alloy. Arching, 24 meter radius barrel roofs cover the three-story building. Terne, comprised of 80% to 85% lead, and the balance tin, was used as early as the 11th century on church roofs in Europe; but terne-coated stainless steel was introduced only in the 1960's according to the Nickel Development Institute, Toronto, Canada. In the Pittsburgh airport, stainless steel provides corrosion resistance and structural integrity in case of fire. The terne coating weathers to a uniform, warm gray after 2 years of exposure. The precise shade depends on the sulfur content of the atmosphere. Terne also enhances corrosion resistance because it is anodic to stainless steel.

A team of professors and researchers at the Ames Laboratory, Ames, IA, began collaboration on development of a new lead-free alloy for use in strong, high-performance solder pastes, thereby eliminating a substantial source of a known environmental toxin. The composition of the lead-free alloy is tin-silver-copper, elements not commonly naturally found with lead. The researchers reported that silver and copper were not oxidation- or corrosion-sensitive and were not derived from lead ores. They also produce very hard intermetallic phases that would reinforce the tin to make a much stronger solder than the tin-lead combination. The team was reportedly leaning toward a powder form of the new solder composition that is made up of particles less than 25 microns in diameter. When these powder particles are blended with a fluxing agent that help clean the alloy and improve flux characteristics, they create a smooth, fluid-like behavior that is critical for convenient and accurate handling of solder paste; that is considered very important to paste manufacturers and users who want to disperse it or screen print onto a circuit board. The team observed that principal potential uses for the lead-free solder paste would be applications in the electronics and automobile industries. For years, electronics firms have been concerned about solder strength because many failures occur after temperatures rise. This is especially typical under the hoods of automobiles, where there are many electronic components and where temperatures can easily reach 150°C (302°F). Lead solder melts at 183°C (361°F). The team's lead-free solder melts at 216°C (421°F), making possible solder connections that retain greater strength at equipment operating temperatures. The team also asserts their solder resists thermo-mechanical fatigue, a problem in which components grow when they get hot, and shrink when they cool back down. The solder joint is in the middle and gets flexed, and tin-lead solder is often not strong enough to resist that. The Ames team claims its solder, at about $4 per pound is at or near the bottom of the price scale for all lead-free solders on the market.

In Utica, NY, Indium Corporation of America introduced a new lead-free solder, Indalloy 227. The solder took 3 years to develop and was introduced commercially after 18 months of testing. Its composition is 77.2% tin, 20% indium, and 2.8% silver. The company claims this solder is the first direct replacement for traditional 67% tin-33% lead solder, with similar melting and reflow characteristics. The firm acknowledged the new solder was more costly than the traditional ore, but still felt that possible emerging legislation against lead (including even the possible imposition of a tax in some applications) would make Indalloy 227 a success.

Outlook

Domestic demand for primary tin is expected to grow slowly in the next few years, at a rate of perhaps 1% per year. However, new applications, especially those in which tin is substituted for toxic materials, could double that rate by the late 1990's.

As long as the price of tin remains historically low, there appears to be little incentive to explore or develop domestic tin reserves. Thus, it seems likely that domestic requirements for primary tin will continue to be met by imports and Government stockpile sales.

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[1] Can Manufacturers Institute. Metal Can Shipment Report 1994. Washington, DC, 1994, pp 1-4.

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TABLE 1
SALIENT TIN STATISTICS 1/

(Metric tons unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production:					
Mine	W	W	W	W	--
Secondary e/	17,200	13,100	13,700	12,000 r/	10,900
Exports 2/	658	970	1,890	2,600	2,560
Imports for consumption:					
Metal	33,800	29,100	27,300	33,700	32,400
Ore (tin content)	--	1	--	--	--
Consumption:					
Primary	36,800	35,100	35,000	34,600 r/	32,900
Secondary	8,400	9,670	10,100	11,900 r/	8,490
Stocks, yearend, U.S. industry	17,300	13,800	10,700	10,800 r/	10,400
Prices, average cents per pound:					
New York market	287.69	258.75	282.58	239.17	254.93
Metals Week composite	386.29	362.85	400.00	300.00	369.14
London	281.00	254.00	277.00	233.00	248.00
Kuala Lumpur	276.02	248.42	271.85	231.58	244.76
World: Production:					
Mine	221,000 r/	201,000 r/	182,000 r/	187,000 r/	183,000 e/
Smelter:					
Primary	223,000	190,000	184,000 r/	185,000 r/	190,000 e/
Secondary	18,000	13,200	8,820 r/	7,740 r/	7,450 e/
Undifferentiated	4,830	1,720	2,150 r/	1,310 r/	1,340 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; U.S. mine production for 1990-1993 was negligible.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Excludes reexports.

TABLE 2
U.S. CONSUMPTION OF PRIMARY AND SECONDARY TIN 1/

(Metric tons)

	1993	1994
Stocks, Jan. 1 2/	8,560	9,530
Net receipts during year:		
Primary	37,700 r/	33,000
Secondary	3,280 r/	4,160
Scrap	8,770	4,930
Total receipts	49,700 r/	42,000
Total available	58,300 r/	51,600
Tin consumed in manufactured products:		
Primary	34,600 r/	32,900
Secondary	11,900 r/	8,490
Total	46,600 r/	41,400
Intercompany transactions in scrap	165	214
Total processed	46,700 r/	41,600
Stocks, Dec. 31 (total available less total processed)	11,600	9,940

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes tin in transit in the United States.

TABLE 3
U.S. CONSUMPTION OF TIN, BY FINISHED PRODUCT 1/

(Metric tons of contained tin)

Product	1993 Primary	1993 Secondary	1993 Total	1994 Primary	1994 Secondary	1994 Total
Alloys (miscellaneous) 2/	W	W	W	W	W	W
Babbitt	486	337	823	350	277	627
Bar tin	946	W	946	855	W	855
Bronze and brass	1,490	1,600	3,090	1,160	1,920	3,080
Chemicals	6,450	W	6,450	5,740	W	5,740
Collapsible tubes and foil	W	W	W	W	W	W
Solder	11,000 r/	8,010 r/	19,000 r/	10,700	4,370	15,000
Tinning	1,250	W	1,250	1,230	W	1,230
Tinplate 3/	9,650 r/	W	9,650 r/	9,480	W	9,480
Tin powder	608	W	608	625	W	625
Type metal	W	W	W	W	W	W
White metal 4/	789	W	789	756	W	756
Other	1,940	1,990	3,930	2,070	1,920	3,990
Total	34,600 r/	11,900 r/	46,600 r/	32,900	8,490	41,400

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes terne metal.

3/ Includes secondary pig tin and tin acquired in chemicals.

4/ Includes pewter, britannia metal, and jewelers' metal.

TABLE 4
U.S. INDUSTRY YEAREND TIN STOCKS 1/

(Metric tons)

	1993	1994
Plant raw materials:		
Pig tin:		
Virgin 2/	7,460 r/	6,650
Secondary	654	706
In process 3/	1,190	1,510
Total	9,300 r/	8,870
Additional pig tin:		
Jobbers-importers	679	373
Afloat to United States	802	1,110
Total	1,480	1,480
Grand total	10,800 r/	10,400

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes tin in transit in the United States.

3/ Data represent scrap only, tin content.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TIN, TIN MANUFACTURES, TINPLATE AND TERNEPLATE, AND TINPLATE SCRAP 1/

Year	Miscellaneous tin and tin manufactures								
	Tinfoil, tin powder, flitters, metallics, manufactures, n.s.p.f.	Dross, skimmings, scrap residues, tin alloys, n.s.p.f.		Tinplate and terneplate		Tin compounds		Tinplate scrap	
	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993	$5,300	8,280	$25,000	237,000	$161,000	431	$3,150	12,600	$1,420
1994	2,840	9,150	39,300	337,000	216,000	744	4,740	8,950	1,410

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF TIN, TINPLATE AND TERNEPLATE IN VARIOUS FORMS, INGOTS, PIGS AND TIN SCRAP 1/

Year	Tinplate and terneplate		Ingots and pigs		Tin scrap and other tin bearing material except tinplate scrap 2/	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993	201,000	$120,000	2,600	$11,400	92,600	$63,200
1994	213,000	123,000	2,560	13,900	68,000	52,800

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Includes rods, profiles, wire, powders, flakes, tubes, and pipes.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT TIN METAL BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Bolivia	8,030	$41,100	7,260	$38,600
Brazil	11,400	59,400 r/	9,990	50,900
Chile	714	3,150	667	3,510
China	4,200	22,400	3,230	16,500
Hong Kong	1,810	10,000	1,210	6,460
India	20	90	120	647
Indonesia	5,680	29,900	6,620	35,100
Japan	--	--	76	659
Korea, Republic of	--	--	100	535
Malaysia	846	4,660	1,390	8,220
Mexico	572	2,950	--	--
Netherlands	20	95	281	1,550
Russia	40	213	325	1,710
Singapore	220	1,100	142	836
United Kingdom	6	54	666	3,480
Other	163 r/	958 r/	334	1,850
Total	33,700	176,000 r/	32,400	171,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 8
TIN: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Argentina	123	--	--	--	--
Australia 3/	7,380	5,700	6,610 r/	8,060 r/	6,400
Bolivia	17,200	16,800	16,500	18,600	16,200 4/
Brazil	39,100	29,300	27,500	26,500 r/	27,000
Burma 5/	596 r/	438 r/	649 r/	689 r/	750
Burundi e/	54	74	110	50	50
Cameroon e/	3	3	3	3	3
Canada	2,830	4,460	--	--	--
China e/	42,000	42,100	43,800 r/	49,100 r/	50,000
Czechoslovakia 6/	590	15	XX	XX	XX
Germany: Eastern states	1,810	118	--	--	--
Indonesia	30,200	30,100	29,400	29,000 e/	34,000
Kazakhstan e/	XX	XX	500	450 r/	400
Laos e/	300 r/ 4/	300	300	300	200
Malaysia	28,500	20,700	14,300	10,400	6,460 4/
Mexico	5	12	1	3 r/	3
Mongolia	320	250	190	150 e/	150
Namibia	900	11	11	4 r/	4
Niger	38	20	20 e/	20 e/	20
Nigeria 7/	192	217	186 e/	186 e/	180
Peru	5,130	6,560	9,680 r/	13,900 r/	14,000
Portugal	4,780 r/	8,330 r/	6,560 r/	10,100 r/	12,000
Russia e/	XX	XX	6,000	5,000	4,100
Rwanda e/	734 8/	730	500	400	50
South Africa, Republic of	1,140	1,040	582	450 r/ e/	-- 4/
Spain	27	12	7 r/	2 r/	--
Tanzania e/	15	6	5	5	5
Thailand	14,600	14,900	11,500	6,380 r/	4,000
Uganda e/	25	25	30 4/	30	30
U.S.S.R. e/ 9/	15,000	13,500	XX	XX	XX
United Kingdom	3,400	2,330	2,040 r/	2,230 r/	1,900
United States	W	W	W	W	--
Vietnam e/	850	800	3,400	3,500	4,000
Zaire	2,220	1,520	1,020	700 e/	700
Zambia	1	6	2	2 e/	2
Zimbabwe e/	1,120	1,060	950	800	800
Total	221,000 r/	201,000 r/	182,000 r/	187,000 r/	183,000

e/ Estimated. r/ Revised. W Witheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Contained tin basis. Data derived in part from the Monthly Statistical Bulletin of the International Tin Council, London. Table includes data available through June 27, 1995.

3/ Excludes tin content of copper-tin and tin-tungsten concentrates.

4/ Reported figure.

5/ Includes content of tin-tungsten concentrate.

6/ Dissolved Dec. 31, 1992.

7/ Concentrate gross weight reported, estimated 62% Sn content.

8/ Concentrate gross weight reported, estimated 70% Sn content.

9/ Dissolved in Dec. 1991.

TABLE 9
TIN: WORLD SMELTER PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Argentina: e/					
Primary	180	240 3/	140	145	100
Secondary	100	100	100	100	100
Total	280	340	240	245	200
Australia:					
Primary	312	268	240 r/	222 r/	240
Secondary e/	200	300	360 r/	250	260
Total e/	512	568	600 r/	472 r/	500
Belgium: Secondary	6,060	4,430	5,260 e/	5,000 e/	5,000
Bolivia: Primary	12,600	14,700	14,400	14,500 r/	15,300
Brazil:					
Primary	37,600	25,800	27,000 r/	26,900 r/	30,000
Secondary e/	250	250	250	250	250
Total e/	37,800	26,000	27,300 r/	27,200 r/	30,300
Bulgaria: Primary and secondary	64	22	23 r/	20 e/	20
Burma: Primary	275	157	189	170 r/	200
Canada: Secondary e/	200	200	200	200	200
China: Primary e/	35,000	36,400	39,600	52,000 r/	53,000
Czech Republic: Primary and secondary e/	XX	XX	XX	115	115
Czechoslovakia: 4/ Primary	613	118	115	XX	XX
Denmark: Secondary e/	100	100	100	100	100
Germany: Primary and secondary	3,360	700	127 r/	179 r/	200
Greece: Secondary e/	700	200	200	200	150
India: Secondary e/	200	200	200	200	200
Indonesia: Primary	30,400	30,400	31,900	30,400 r/	31,100
Japan: Primary	816	716	821	804 r/	706 3/
Korea, Republic of: Primary e/	800	600	400	400	300
Malaysia: Primary	49,100	42,700	45,600	40,100 r/	42,000
Mexico: Primary	5,000	2,260	2,590 r/	1,640 r/	1,700
Netherlands:					
Primary	5,900	4,800	--	--	--
Secondary e/	200	200	200	-- r/	--
Total e/	6,100	5,000	200	-- r/	--
Nigeria: Primary	227	246	220	220 e/	200
Norway: Secondary e/	100	90	90	90	90
Portugal: Primary and secondary e/	1,400 3/	1,000	2,000	1,000	1,000
Russia: e/ 5/					
Primary	XX	XX	6,000	5,000	4,100
Secondary	XX	XX	1,500	1,000	800
Total	XX	XX	7,500	6,000	4,900
Singapore: Primary e/	2,500	600	--	--	--
South Africa, Republic of:					
Primary	1,140	1,040	592	452 r/	--
Secondary e/	70	70	60	45	--
Total e/	1,210	1,110	652	497 r/	--
Spain: e/					
Primary	600	600	600	500	700
Secondary	200	200	200	200	200
Total	800	800	800	700	900
Thailand: Primary	15,500	11,300	10,700	8,100 r/	8,100
U.S.S.R.: e/ 5/ 6/					
Primary	16,000	13,000	XX	XX	XX
Secondary	3,700	3,300	XX	XX	XX
Total	19,700	16,300	XX	XX	XX
United Kingdom:					
Primary	6,100 e/	1,660	--	--	--
Secondary	5,900 e/	3,580	100	100 e/	100
Total	12,000 e/	5,240	100	100 e/	100
United States: Secondary	W	W	W	W	W

See footnotes at end of table.

TABLE 9--Continued
TIN: WORLD SMELTER PRODUCTION, BY COUNTRY 1/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Vietnam: Primary e/	1,800	1,700	2,400	2,500	2,500
Zaire: Primary e/	90	70	50	20 r/	20
Zimbabwe: Primary	838	796	716	657	82 3/ 7/
Total primary	223,000	190,000	184,000 r/	185,000 r/	190,000
Total secondary	18,000	13,200	8,820 r/	7,740 r/	7,450
Total undifferentiated	4,830	1,720	2,150 r/	1,310 r/	1,334
Grand total	246,000	205,000	195,000 r/	194,000 r/	199,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Data for 1990 are derived in part from UNCTAD. Wherever possible, total smelter output has been separated into primary (from ores and concentrates) and secondary (tin metal recovered from old scrap). This table reflects metal production at the first measurable stage of metal output. Table includes data available through June 27, 1995.

3/ Reported figure.

4/ Dissolved Dec. 31, 1992. All production in Czechoslovakia from 1990-92 came from the Czech Republic.

5/ All production in the U.S.S.R. from 1990-91 came from Russia.

6/ Dissolved in Dec. 1991.

7/ Kamativi mine closed in 1994.

TITANIUM

By Joseph M. Gambogi

Titanium (Ti) is a lightweight metal well known for corrosion resistance and its high strength-to-weight ratio. Titanium comprises about 0.62% of the Earth's crust and occurs primarily in the minerals, anatase, brookite, ilmenite, leucoxene, perovskite, rutile, and sphene. Although titanium is best known for its use as a metal alloy, it is primarily used in the form of titanium dioxide (TiO_2) as a white pigment in paints, paper, and plastics. Other minor uses of titanium minerals include ceramics, chemicals, welding rod coatings, heavy aggregate, and steel furnace flux.

An expanding world economy drove demand for titanium minerals and pigments upward in 1994. According to industry reports, global consumption of TiO_2 pigment grew by an estimated 5%, the highest growth rate since 1989. Demand for titanium mineral ores and concentrates (feedstocks) underwent a similar growth rate. Increased demand for TiO_2 pigment was met though higher production levels. However, increased demand for mineral feedstocks was met though a reduction in inventory levels. Domestic production of TiO_2 pigment was at a record level. Overall imports of mineral feedstocks and TiO_2 pigment were nearly unchanged. *(See table 1.)*

Legislation and Government Programs

At yearend 1994, the Defense Logistics Agency (DLA) Defense National Stockpile Center (DNSC) held an inventory of 18,895 short dry tons of rutile. Under a modernization program, all of the rutile held in the stockpile was authorized for disposal. For much of the year, rutile was offered for sale each month on a sealed bid basis, and several offers were awarded. In December, DLA offered rutile under a consolidated solicitation of offers on a long-term basis. The new solicitation format allowed the Government to negotiate issues regarding price, quantity, or any other provision of the solicitation. The DNSC inventory in December also contained 25,964 short tons of stockpile grade titanium sponge metal and 10,866 tons of nonstockpile grade material.

Production

U.S. producers of ilmenite in 1994 were RGC (USA) Mineral Sands, Inc. at Green Cove Springs, FL; E. I. du Pont de Nemours & Co. Inc. (Du Pont), Starke, FL, both from mineral sands deposits; and P. W. Gillibrand Co., Simi Valley, CA, as a coproduct of its rock, sand, and gravel operations. RGC was the only U.S. producer of natural rutile. Kerr-McGee Chemical Corp. was the sole domestic producer of synthetic rutile at Mobile, AL.

Teck Resources Inc. was reported to be studying the development of the large Powderhorn perovskite deposit near Gunnison, CO. However, the successful development of the deposit required the development of a unique commercial process of extracting TiO_2 from the perovskite ore.[1]

Ferrotitanium was produced by Galt Alloys Inc., Canton, OH, and Shieldalloy Metallurgical Corp., Newfield, NJ. The two standard grades produced were 40% and 70% titanium. Data on production of ferrotitanium were not available.

Titanium sponge metal was produced by Oregon Metallurgical Corp. (Oremet), Albany, OR, and Titanium Metals Corp. Of America (Timet), Henderson, NV. Titanium ingot was produced by the two sponge producers and by nine other firms in seven States. About 30 companies are known to produce titanium mill products and castings. Production of ingot and increased by 6% while mill product production decreased by about 5%. Production of titanium sponge was withheld to avoid disclosing company proprietary data. *(See tables 2 and 3.)*

Production at Timet's new Vacuum Distillation Process (VDP) titanium sponge plant at Henderson, NV, was temporarily interrupted by a failure in the shearing operation. The shearing failure caused the company to restart the older sponge plant at Henderson that had been shut down in 1993. At midyear, Timet ended a 12-month strike at the Henderson facility. Later in the year, Timet ended a 3-month strike at its mill product facility at Toronto, OH.

U.S. producers of titanium dioxide pigments were Du Pont, Kemira, Inc., Kerr-McGee, Louisiana Pigment Co. LP (formerly Kronos Inc.), and SCM Chemicals Inc.. U.S. production of TiO_2 pigment in 1994 was 8% higher than in 1993. Capacity utilization for the domestic pigment industry was about 93%. *(See tables 4 and 5.)*

Consumption

On a gross weight basis, U.S. reported consumption of TiO_2 in titanium slag and rutile concentrates increased 8% from the 1993 level. Consumption of ilmenite was withheld to avoid disclosing company proprietary data.

Consumption data for titanium materials are developed by the U.S. Bureau of Mines (USBM) from one voluntary survey of domestic operations. Of the 32 operations canvassed, 28 responded, representing 85% of the data in table 6. Data for nonrespondents were estimated based on prior year consumption levels. *(See table 6.)*

Reported consumption of titanium in the form of ferrotitanium and scrap in steel and other alloys was 6,090 metric tons, a 3% increase from the 1993 level. Carbon, stainless, and heat-resisting steels were the largest end-use categories of ferrotitanium and scrap.

Increased ingot production caused titanium sponge and scrap consumption to increase by 14% and 3%, respectively. Scrap supplied a calculated 53% of ingot feedstock. Poor demand for titanium mill products resulted in a 5% decrease in ingot consumption and in mill product shipments. Reflecting the strong demand for titanium castings, castings shipments increased by about 15%. Estimated U.S. mill product usage by application was as follows: commercial aerospace, 49%; military aerospace, 23%; and nonaerospace uses, 28%. Nonaerospace uses include those in the specialty chemical, pulp and paper, oil and gas, marine, and medical industries.

Titanium dioxide pigments account for over 95% of all prime white pigments and are produced as two major types: rutile and anatase pigment. The three largest end uses are paint and coatings, paper, and plastics. Other consuming industries included ceramics, fabrics and textiles, floor coverings, printing ink, and rubber. Apparent domestic consumption of TiO_2 pigments was about 1.09 million tons, 6% more than in 1993. *(See tables 7 and 8.)*

Stocks

Based on TiO_2 content, consumer inventories of titanium concentrates decreased 25%. Producer stocks of TiO_2 pigments were about 106,000 tons, a 14% increase from 1993. Reflecting an increased reliance on imported sources of titanium sponge, industry stocks of sponge increased 92%. Stocks of titanium scrap were nearly unchanged. *(See table 9.)*

Prices

Published prices for titanium concentrates, pigments, and metal are presented in table 10. However, published prices do not always agree with market trends. Based on the customs value of imported sponge, the price for titanium sponge decreased significantly in 1994. Increased demand for titanium concentrates by the pigment industry resulted in a significant increase in the price for ilmenite. Based on the U.S. Customs Service value of imports, prices for ilmenite, titanium slag, natural rutile, and synthetic rutile were estimated to have increased 28%, 6%, 1%, and 8%, respectively. Published prices for titanium pigments decreased slightly. *(See table 10.)*

Foreign Trade

Kazakhstan and Ukraine were granted General System of Preferences (GSP) status by the President of the United States. Under the GSP program, selected products are eligible to enter the United States duty-free. Titanium mill products and castings are included on the list of eligible products.

The U.S. Department of Commerce, International Trade Administration (ITA), revoked antidumping findings on titanium sponge from Armenia, Azerbaijan, Belarus, Estonia, Kyrgyzstan, Latvia, Lithuania, Moldova, Tajikistan, Turkmenistan, and Uzbekistan. The countries listed on the finding were not known to produce titanium sponge, and domestic producers did not object to the revocation.

The ITA published the final results of an antidumping duty administrative review covering exports of titanium sponge to the United States from Kazakhstan. The ITA concluded that no shipments took place during the period of review and let stand the 83.96% rate established in the last review.

The ITA also completed an administrative review of an antidumping order on titanium sponge from Japan. The ITA found no dumping margin for Showa Denko K.K. (Showa) and determined that Showa met the requirements for revocation. *(See tables 11, 12, 13, and 14.)*

World Review

Capacity.—The capacity data in this report are for mines and beneficiation plants, sponge metal facilities, and TiO_2 pigment plants as of December 31, 1994. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time at a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and temporarily closed facilities that, in the opinion of the author, can be brought into production within a short period of time and with minimum capital expenditure. Mine and mill capacity for the production of titanium concentrates, metal production plant capacity, and TiO_2 pigment plant capacity are generally based on close to 365 days per year operation, 3 shifts per day. Capacity figures are based on information obtained from the producing companies, from news items, and from USBM estimates.

Reflecting improved global demand for TiO_2 pigment, several companies were developing programs to produce titanium mineral concentrates. Almost all of the new projects were focused on producing higher TiO_2 grades of mineral feedstocks.

In response to industry estimates of improved TiO_2 demand, several TiO_2 pigment producers announced plans to expand pigment capacity on a global basis. At present, most of the expansions are to be made through debottlenecking of existing plants. Du Pont plans a 185,000-ton-per-year increase in capacity by 1997. The Tioxide Group PLC plans to increase its capacity by 115,000 tons per year and SCM Chemical is debottlenecking several plants to raise its total capacity by 52,000 tons per year. Kerr-McGee announced plans to increase pigment capacity by 30,000 tons per year in 1995 and may add 55,000 tons per year by 1997 if market conditions are favorable.[2] *(See table 15.)*

Australia.—Cable Sands Ltd. commissioned its Jangardup mineral sands operation in Western Australia. The new operation was expected to double Cable Sands' mine capacity. BHP Minerals announced plans to proceed with the development of its Beenup deposit in Western Australia. Ilmenite concentrate produced at Beenup is expected to be used as a feedstock for the Tinfos Titan & Iron KS slag operations at Tyssedal, Norway.[3]

Canada.—Tiomin Resources continued to study the development of its mineral deposit near Natashquan, Quebec. Tiomin announced the completion of the first stage of the project in June 1994. After completing a prefeasibility review, Tiomin concluded that the project is feasible from technological, engineering, environmental, and economic standpoints.[4]

Japan.—Showa Titanium Co., one of the three producers of titanium sponge in Japan, closed its 3,000-ton-per-year sponge facility at Chigasaki. Showa Titanium was a subsidiary of Showa Denko K.K. The closure will leave Japan with about 25,800 tons of annual capacity. The remaining titanium sponge producers were Sumitomo Sitix Corp. and Toho Titanium Co.

Russia.—Aircraft builder Boeing Co., Seattle, WA, qualified the Russian titanium ingot and mill product producer Verkhnesaldinskoye Metallurgical Production Association (Salda) as a supplier of a specific grade of ingot used in airframes. In 1994, Salda was the largest producer of titanium mill products in the world, with an estimated capacity of more than 100,000 tons per year.

South Africa.—Anglo American Corp. commissioned its Namakwa Sands project. Production of ilmenite concentrate commenced in midyear, and production of titanium slag was expected to begin in 1995. Iscor announced plans to acquire Natal Mineral Sands (Pty.) Ltd. Following the acquisition, Iscor planned to pursue the development of two heavy mineral deposits in Natal and Transkei. Iscor's future plan called for the capability to produce titanium slag and TiO_2 pigment. A feasibility study to develop the Natal deposit was expected to be conducted during the next year. Late in 1994, maintenance downtime and a labor strike at Richards Bay Minerals interrupted slag production at Natal.[5]

Taiwan.—Du Pont started production of TiO_2 pigment from the front end of its new TiO_2 pigment plant at Kuan Yin, Taiwan. The finishing end of the plant was commissioned in early 1994 and was temporarily supplied with pigment from other Du Pont facilities. The new plant adds 60,000 tons per year of chloride-process capacity.[6]

Outlook

For the next few years, global demand for titanium pigments is expected to grow between 3% and 4% annually. The Latin America and Asia/Pacific regions are anticipated to experience a somewhat higher growth rate. Initially, increased demand is expected to be met through debottlenecking of existing TiO_2 capacity. At the same time, some facilities may be forced to close because of environmental pressures to regulate effluent levels.

Because demand for mineral feedstocks is driven by demand for TiO_2 pigments, feedstock demand is expected to increase moderately for the next few years. Concurrent with increased demand, consumers of mineral feedstocks are expected to demand higher grades of TiO_2 material, such as high-grade ilmenite (60% TiO_2), natural and synthetic rutile, and titanium slag. Another factor that is shaping demand for minerals feedstocks is the rising concern over naturally occurring radioactive elements found in ore deposits. Several countries have proposed regulating the allowable radioactivity level for titanium feedstocks. Consequently, producers are exploring methods to reduce the radioactivity of titanium feedstocks or developing deposits with naturally low levels of radioactivity.

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[1] Industrial Minerals. Teck Acquires TiO_2 Project. No. 328, Jan. 1995, p. 17.

[2] Chemical Marketing Reporter. TiO_2 Balance Tips to the Tight Side. V. 246, No.18, Nov. 4, 1994, p. 9.

[3] Industrial Minerals. Jangarup Enters Production, No. 322, July 1994, p. 74.

[4] ———. Tiomin Minsands Project Advances. No. 323, Aug. 1994, p. 11.

[5] ———. Iscor Buys Mineral Sands. No. 322, July 1994, p. 13.

[6] European Chemical News. Du Pont Startup Dents U.S. TiO_2. V. 61, No. 1615, Apr. 25, 1994, p. 10.

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Titanium. Reported quarterly in Mineral Industry Surveys.
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Titanium Development Association (Boulder, CO)

TABLE 1
SALIENT TITANIUM STATISTICS 1/

(Metric tons unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Ilmenite concentrate:					
Imports for consumption	346,000	214,000	295,000	301,000	336,000
Consumption 2/	689,000	738,000	685,000	694,000	W
Titanium slag:					
Imports for consumption	374,000	408,000	537,000	476,000	472,000
Consumption	391,000	341,000	539,000	546,000	583,000
Rutile concentrate, natural and synthetic:					
Imports for consumption	275,000	240,000	317,000	371,000	332,000
Consumption	369,000	369,000	461,000	465,000	510,000
Sponge metal:					
Production	24,700	13,400	W	W	W
Imports for consumption	1,090	612	684	2,160	6,470
Consumption	23,200	13,600	14,200	15,100	17,200
Price, Dec. 31, per pound	$4.50-$5.00	$4.50-$5.00	$3.50-$4.00	$3.50-$4.00	3.75-$4.25
Titanium dioxide pigment:					
Production	979,000	992,000	1,140,000	1,160,000	1,250,000
Imports for consumption	148,000	166,000	169,000	172,000	176,000
Consumption, apparent 3/	925,000	936,000	1,000,000	1,030,000	1,100,000
Price, Dec. 31, cents per pound:					
Anatase	99	99	99	99	94-96
Rutile	100	99	92-95	92-95	92-94
World production:					
Ilmenite concentrate 4/	4,070,000	3,410,000	3,580,000	3,580,000	3,440,000
Rutile concentrate, natural 4/	481,000	458,000	442,000	464,000	459,000
Titaniferous slag	1,890,000	1,510,000	1,640,000	1,550,000	1,510,000

W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; except prices.

2/ Includes consumption to produce synthetic rutile.

3/ Production plus imports minus exports plus stock decrease or minus stock increase.

4/ Excludes U.S. production data to avoid disclosing company proprietary data.

TABLE 2
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 1994 1/

Company	Plant location	Yearend capacity (metric tons)	
		Sponge	Ingot 2/
Howmet Corp., Titanium Ingot Div.	Whitehall, MI	--	2,300
A. Johnson Metals Corp.	Morgantown, PA	--	2,300 3/
Lawrence Aviation Industries Inc.	Port Jefferson, NY	--	1,400
Oregon Metallurgical Corp. (Oremet)	Albany, OR	6,800	7,300
RMI Co.	Niles, OH	--	16,300
Teledyne Allvac	Monroe, NC	--	7,300
Teledyne Wah Chang Albany	Albany, OR	--	900
Titanium Hearth Technologies of America	Morgantown, PA	--	4,500
Titanium Metals Corp. of America	Henderson, NV	22,700	13,600
Viking Metallurgical Corp.	Verdi, NV	--	2,300 3/
Wyman-Gordon Co.	Worcester, MA	--	3,200 4/
Total		29,500	61,400

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Based on 7-day-per-week full production. Includes 55,400 tons vacuum-arc double-triple melt, of which triple melt generally ranged from 10% to 30%. The remaining 6,000 tons was single melt (electron-beam and plasma) capacity.

3/ Single melt only.

4/ Includes 1,400 tons of single melt capacity.

TABLE 3
COMPONENTS OF U.S. TITANIUM METAL SUPPLY AND DEMAND 1/

(Metric tons)

Component	1993	1994
Production:		
Sponge	W	W
Ingot	27,900	29,500
Mill products	18,900	17,900
Exports:		
Sponge	104	126
Other unwrought	654	297
Scrap	3,890	4,120
Ingot, slab, sheet bar, etc.	857	1,260
Other articles of titanium	2,390	3,850
Total	7,890	9,660
Imports:		
Sponge	2,160	6,470
Scrap	5,520	5,870
Ingot and billet	272	1,730
Other unwrought	168	723
Other wrought (mill products)	497	675
Other articles of titanium	103	127
Total	8,720	15,600
Stocks, yearend:		
Government: Sponge (total inventory)	33,400	33,400
Industry:		
Sponge	2,910	5,570
Scrap	8,130	7,930
Ingot	2,430	3,270
Other	W	W
Total industry	13,500	16,800
Reported consumption:		
Sponge	15,100	17,200
Scrap	15,300	15,700
Receipts:		
Home	8,240	9,090
Purchased	9,870	11,300
Ingot	25,700	24,300
Mill products (net shipments):	16,500	15,600
Forging and extrusion billet	6,940	5,910
Rod and bar	2,150	2,070
Other 2/	7,440	7,670
Castings (shipments)	469	540

W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Data for sheet and strip, plate, extrusions (other than tubing), pipe and tubing, and other have been combined to avoid disclosing company proprietary data.

TABLE 4
CAPACITIES OF U.S. TITANIUM DIOXIDE PIGMENT PLANTS ON DECEMBER 31, 1994 1/ 2/

Company	Plant location	Pigment capacity (metric tons per year)	
		Sulfate process	Chloride process
E. I. du Pont de Nemours & Co. Inc.:	Antioch, CA	--	40,000
	De Lisle, MS	--	245,000
	Edge Moor, DE	--	129,000
	New Johnsonville, TN	--	297,000
Kemira, Inc.	Savannah, GA	54,000	91,000
Kerr-McGee Chemical Corp.	Hamilton, MS	--	114,000
Louisiana Pigment Co. LP	Lake Charles, LA	--	100,000
SCM Chemicals Inc.:	Ashtabula, OH	--	165,000
	Baltimore, MD	66,000	50,000
Total		120,000	1,230,000

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table does not include Hitox Corp.'s Corpus Christi, TX, production capacity of about 16,400 tons per year of buff TiO2 pigment that is produced by refining and fine grinding of synthetic rutile.

TABLE 5
COMPONENTS OF U.S. TITANIUM DIOXIDE PIGMENT SUPPLY AND DEMAND 1/

(Metric tons unless otherwise specified)

Component	1993		1994	
	Gross weight	TiO2 content	Gross weight	TiO2 content
Production 2/	1,160,000	1,090,000	1,250,000	1,180,000
Shipments: 3/				
Quantity	1,290,000	1,200,000	1,370,000	1,260,000
Value thousands	$2,480,000	$2,480,000	$2,540,000	$2,540,000
Exports	290,000	272,000 e/	352,000	331,000 e/
Imports for consumption	172,000	161,000 e/	176,000	165,000 e/
Stocks, yearend	123,000	116,000 e/	106,000	99,300 e/
Consumption, apparent 4/	1,030,000	966,000 r/ e/	1,090,000	1,030,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Excludes production of buff pigment.

3/ Includes interplant transfers.

4/ Production plus imports minus exports plus stock decrease or minus stock increase.

Sources: Bureau of the Census and U.S. Bureau of Mines.

TABLE 6
U.S. CONSUMPTION OF TITANIUM CONCENTRATES 1/

(Metric tons)

	Ilmenite 2/ 3/		Titanium slag		Rutile (natural and synthetic) 4/	
	Gross weight	TiO2 content	Gross weight	TiO2 content	Gross weight	TiO2 content
1993:						
Pigments	693,000	434,000	546,000	454,000	433,000	406,000
Miscellaneous 5/	733	451	(6/)	(6/)	31,900	30,200
Total	694,000	435,000	546,000	454,000	465,000	436,000
1994:						
Pigments	W	W	583,000	479,000	491,000	460,000
Miscellaneous 5/	1,000	637	(6/)	(6/)	19,800	18,500
Total	W	W	583,000	479,000	510,000	478,000

W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

3/ Includes ilmenite consumed to produce synthetic rutile.

4/ Includes synthetic rutile made in the United States.

5/ Includes alloys, carbide, welding-rod coatings, fluxes, ceramics, chemicals, glass fibers, and titanium metal.

6/ Included with "Pigments" to avoid disclosing company proprietary data.

TABLE 7
U.S. DISTRIBUTION OF DOMESTIC TITANIUM PIGMENT SHIPMENTS, TITANIUM DIOXIDE CONTENT, BY INDUSTRY

(Percent)

Industry	1993	1994
Ceramics	0.3	0.2
Coated fabrics and textiles	.4	.4
Floor coverings	1.0	1.0
Paint, varnish, lacquer	46.0	46.7
Paper	26.2	23.8
Plastics	17.9	18.0
Printing ink	1.5	1.5
Roofing granules	W	W
Rubber	1.9	2.1
Other	4.8	6.3
Total	100.0	100.0

W Withheld to avoid disclosing company proprietary data; included in "Other."

TABLE 8
U.S. CONSUMPTION OF TITANIUM PRODUCTS 1/ 2/ IN STEEL AND OTHER ALLOYS

(Metric tons)

	1993	1994
Carbon steel	2,060	2,390
Stainless and heat-resisting steel	2,100	1,930
Other alloy steel (includes HSLA)	472	408
Tool steel	W	W
Total steel	4,630	4,720
Cast irons	W	W
Superalloys	504	609
Alloys, other than above	455	456
Miscellaneous and unspecified	357	299
Total consumption	5,940	6,090

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

1/ Includes ferrotitanium, titanium scrap, and other titanium additives.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 9
U.S. STOCKS OF TITANIUM CONCENTRATES AND PIGMENT, DECEMBER 31 1/

(Metric tons)

Concentrates	1993		1994	
	Gross weight	TiO2 content	Gross weight	TiO2 content
Ilmenite 2/	173,000	105,000	72,700	43,900
Titanium slag 2/	137,000	113,000	135,000	113,000
Rutile 2/	190,000	179,000	149,000	141,000
Titanium pigment 3/	123,000	116,000 e/	106,000	99,300 e/

e/ Estimated.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Consumer stocks.

3/ Bureau of the Census. Producer stocks only.

TABLE 10
PUBLISHED PRICES OF TITANIUM CONCENTRATES AND PRODUCTS 1/

		1993	1994
Concentrates:			
Ilmenite, f.o.b. Australian ports	per metric ton	$61.00-$64.00	$74.00-$80.00
Rutile, bagged, f.o.b. Australian ports	do.	370.00-400.00	450.00-480.00
Rutile, bulk, f.o.b. Australian ports	do.	365.00-390.00	410.00-430.00
Titanium slag, 80% TiO2, Canada e/	do.	276.00	278.00
Titanium slag, 85% TiO2, Republic of South Africa e/	do.	330.00	334.00
Metal:			
Sponge	per pound	3.50- 4.00	3.75- 4.25
Ferrotitanium:	do.	1.15- 1.20	1.60- 1.72
Scrap:			
Turnings, unprocessed	do.	.40- .45	.75- .80
Pigment:			
Titanium dioxide pigment, f.o.b. U.S. plants, anatase	do.	.99	.94- .96
Titanium dioxide pigment, f.o.b. U.S. plants, rutile	do.	.92- .95	.92- .94

e/ Estimated.

1/ Yearend.

Sources: American Metal Market, American Paint and Coatings Journal, Chemical Marketing Reporter, Industrial Minerals (London), Metal Bulletin, Platt's Metals Week, and industry contacts.

TABLE 11
U.S. EXPORTS OF TITANIUM PRODUCTS, BY CLASS 1/

Class	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Metal:				
Sponge	104	$748	126	$738
Scrap	3,890	9,070	4,120	7,440
Other unwrought:				
Billet	240	4,790	258	5,250
Blooms and sheet bars	342	6,280	630	12,000
Ingot	275	4,010	374	5,970
Other	654	12,000	297	4,440
Wrought:				
Bars and rods	663	18,000	863	22,500
Other	1,720	54,700	2,990	108,000
Total	7,890	110,000	9,660	166,000
Ores and concentrates	15,200	4,890	19,000	6,070
Pigment and oxides:				
Titanium dioxide pigments	261,000	363,000	313,000	429,000
Titanium oxides	29,200	41,900	39,300	55,800
Total	290,000	405,000	352,000	485,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, may not add to totals shown.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATES, BY COUNTRY 1/

Concentrate and country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ilmenite:				
Australia	233,000	$12,500	278,000	$18,600
India	40,100	2,610	4,150	2,770
Other	27,900 r/	3,320 r/	53,700	4,860
Total	301,000	18,400	336,000	26,200
Titanium slag:				
Canada	88,400	24,200	44,900	12,500
Norway	10,600	2,920	(2/)	(2/)
South Africa, Republic of	377,000	123,000	413,000	141,000
Other	--	--	14,400	4,770
Total	476,000	150,000	472,000	158,000
Rutile, natural:				
Australia	79,900	29,600	83,600	32,300
Sierra Leone	55,100	21,000	45,300	19,500
South Africa, Republic of	140,000	50,800	92,700	31,100
Other	270 r/	431 r/	107	77
Total	275,000	102,000	222,000	82,900
Rutile, synthetic:				
Australia	90,200	29,800	105,000	39,100
Malaysia	6,410	3,370	5,250	2,720
Other	5	2	1	3
Total	96,600	33,200	110,000	40,900
Titaniferous iron ore: 3/				
Canada	66,300	2,850	43,700	2,270

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Revised to zero.

3/ Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel-furnace flux.

Source: Bureau of the Census. Data adjusted by the U.S. Bureau of Mines.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENTS, BY COUNTRY 1/

Country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
80% or more titanium dioxide:				
Belgium	1,590	$2,490	905	$1,390
Canada	33,600	57,500	44,600	70,000
China	1,770	1,640	2,310	2,190
Finland	4,750	7,590	3,060	5,170
France	5,380	8,590	6,360	9,300
Germany	14,600	28,600	20,000	38,200
Japan	5,480	10,800	6,310	12,100
Norway	5,470	9,380	4,310	6,660
Singapore	6,300	9,490	4,700	6,950
United Kingdom	3,320	5,030	2,670	3,560
Other	10,600 r/	15,700 r/	10,300	14,700
Total	93,000	157,000	106,000	170,000
Other titanium dioxide:				
Canada	6,160	10,500	15,400	23,300
France	9,510	14,400	7,320	9,630
Germany	3,010	9,580	1,740	7,640
Italy	532	900	601	889
South Africa, Republic of	6,870	9,890	7,960	10,100
Spain	7,070	10,500	2,620	3,530
United Kingdom	18,300	27,000	7,540	11,500
Other	2,890 r/	5,480 r/	3,450	7,250
Total	54,300	88,200	46,600	73,900
Titanium oxide:				
Belgium	2,730	4,130	1,800	2,540
Canada	8,360	12,700	10,100	15,700
France	6,710	9,370	3,720	5,450
Germany	2,710	4,360	2,840	4,710
Norway	1,240	2,050	895	1,370
Other	2,880 r/	6,020 r/	4,370	9,260
Total	24,600	39,100	23,700	39,000
Grand total	172,000	284,000	176,000	283,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown

Source: Bureau of the Census.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY 1/

Class and country	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Unwrought:				
Sponge:				
China	180	$1,330 r/	86	$452
Japan	338	2,830	819	5,690
Russia	1,160	3,910 r/	5,460	15,400
Ukraine	292	727 r/	--	--
United Kingdom	101	1,310	94	975
Other	89	375	4	7
Total	2,160	10,500	6,470	22,500
Waste and scrap:				
Canada	186	447	214	364
France	559	1,770	307	1,030
Germany	986	3,060	425	1,130
Japan	1,180	4,610	1,560	5,480
Russia	578	1,620	1,140	3,540
United Kingdom	1,500	4,760	1,430	4,560
Other	429 r/	1,510 r/	794	2,970
Total	5,520	18,100	5,870	19,100
Ingot and billets:				
Russia	109	578	377	2,330
United Kingdom	160	2,030	749	9,530
Other	2 r/	428 r/	603	3,640
Total	272	3,030	1,730	15,500
Powder	37	813	79	981
Other: 2/				
United Kingdom	36	167	176	504
Other	95 r/	594 r/	469	4,040
Total	131	761	644	4,540
Wrought products and castings: 3/				
Japan	231	6,710	320	11,900
Russia	33	299	107	1,140
United Kingdom	195	5,370	178	5,490
Other	141 r/	4,860 r/	196	5,140
Total	600	17,200	801	23,700

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes blooms, sheet, bars, slabs, and other unwrought.

3/ Includes bars, castings, foil, pipes, plates, profiles, rods, sheet, strip, tubes, wire, and other.

Source: Bureau of the Census.

TABLE 15
TITANIUM: WORLD PRODUCTION OF CONCENTRATES (ILMENITE, LEUCOXENE, RUTILE, AND TITANIFEROUS SLAG), BY COUNTRY 1/ 2/

(Metric tons)

Concentrate type and country	1990	1991	1992	1993	1994 e/
Ilmenite and leucoxene: 3/					
Australia:					
Ilmenite	1,600,000	1,360,000	1,790,000 r/	1,800,000 r/	1,770,000
Leucoxene	19,000	18,000	20,000 r/	21,000 r/	35,000
Brazil 4/	114,000	69,100	76,600 r/	90,600 r/	91,000
China e/	150,000	150,000	150,000	155,000	155,000
India e/	280,000	312,000 5/	300,000	320,000	300,000
Malaysia	530,000	336,000	338,000	289,000 r/	116,000 5/
Norway	814,000	625,000	708,000	713,000 r/	700,000
Portugal e/	45	40	30	25	25
Sierra Leone	54,600	60,400	60,300	62,900	47,000 5/
Sri Lanka	66,400	60,900	33,300	76,900	60,400 5/
Thailand	10,700	17,100	2,970 r/	20,800 r/	16,000
Ukraine e/ 6/	XX	XX	250,000 r/	200,000 r/	150,000
U.S.S.R. e/ 6/ 7/	430,000	350,000 r/	XX	XX	XX
United States	W	W	W	W	W
Total	4,070,000	3,360,000 r/	3,720,000 r/	3,750,000	3,440,000
Rutile:					
Australia	245,000	201,000	183,000 r/	186,000 r/	223,000
Brazil	1,810	1,090	1,800 r/	1,740 r/	1,800
India e/	11,000	13,600 5/	10,000	13,900	14,000
Sierra Leone	144,000	155,000	149,000	152,000	137,000 5/
South Africa, Republic of e/	64,100 5/	77,000 r/	84,000 r/	85,000	78,000
Sri Lanka	5,460	3,090	2,740	2,640	2,410 5/
Thailand	--	76	281	87 r/	100
Ukraine e/ 6/	XX	XX	5,000	4,000	3,000
U.S.S.R. e/ 6/ 7/	9,500	9,000	XX	XX	XX
United States	W	W	W	W	W
Total	481,000	460,000 r/	436,000 r/	445,000 r/	459,000
Titaniferous slag: 8/					
Canada 9/	1,050,000	701,000	753,000	653,000	764,000 5/
South Africa, Republic of 10/ 11/	672,000 r/	808,000	884,000	892,000	744,000
Total	1,720,000	1,510,000	1,640,000	1,550,000	1,510,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not ad to totals shown.

2/ Table includes data available through July 26, 1995.

3/ Ilmenite is also produced in Canada and in the Republic of South Africa, but this output is not included here because an estimated 90% of it is duplicative of output reported under "Titaniferous slag," and the rest is used for purposes other than production of titanium commodities, principally steel furnace flux and heavy aggregate.

4/ Excludes production of unbeneficiated anatase ore.

5/ Reported figure.

6/ All production in the U.S.S.R. from 1990-91 came from Ukraine.

7/ Dissolved in Dec. 1991.

8/ Slag is also produced in Norway but is not included under "Titaniferous slag" to avoid duplicative reporting. Beginning in 1990, about 25% of Norway's ilmenite production was used to produce slag containing 75% TiO_2.

9/ Refined scorel slag contained 80% TiO_2 in 1990. TiO_2 content in 1991-94 is not reported.

10/ Contains 85% TiO_2.

11/ Excludes 42,000 to 48,000 metric tones of titanium slag from Highveld Steel.

TRIPOLI AND SPECIAL SILICA STONE

By Gordon T. Austin

Tripoli

The category of tripoli, as broadly defined, is composed of extremely fine-grained crystalline silica in various stages of aggregation. The particle sizes usually range from 1 to 10 micrometers, but particles as small as 0.1 to 0.2 micrometers are common. Commercial tripoli contains 98% to 99% silica and minor amounts of alumina (as clay) and iron oxide. Tripoli may be white or some shade of yellow, brown, or red depending on the percentage of iron oxide. The U.S. Bureau of Mines (USBM) includes not only tripoli, but other fine-grained, porous silica materials that have similar properties and end uses such as rottenstone and novaculite. It does not include fine-grained or porous silica materials included in other Annual Mineral Industry Survey reports, such as pumice.

Production.—In 1994, the quantity of crude tripoli produced decreased 6% to 88,700 tons and the value of production decreased 3% to $3.4 million. In the United States, four firms produced tripoli. Malvern Minerals Co., Garland County, AR, produced crude and finished material. Malvern also produces a black material from novaculite. American Tripoli Co. produced crude material in Ottawa County, OK, and finished material in Newton County, MO. Unimin Specialty Minerals Inc.'s Alco and Tamms plants, in Alexander County, IL, produced crude and finished material. Keystone Filler and Manufacturing Co. in Northumberland County, PA, processed rottenstone, a decomposed fine-grained siliceous shale, produced by B. J. Ulrich & Sons, also in Northumberland County, PA. All of the firms responded to the USBM voluntary survey.

Consumption.—Processed tripoli, sold or used, increased 5% in quantity to 82,300 tons and decreased 30% in value to $10.9 million, compared with those of 1993. *(See table 1.)*

Tripoli has had unique uses as an abrasive because of its hardness and its grains lack distinct edges and corners. It is a mild abrasive, making it suitable for use in toothpaste and tooth polishing compounds, industrial soaps, and metal and jewelry polishing compounds. The automobile industry uses it in buffing and polishing compounds in lacquer finishing.

The end-use pattern for tripoli has change significantly in the past 20 years. In 1970, nearly 70% of the processed tripoli was used as an abrasive. Today, 76% is used as a filler and extender in paint, plastic, rubber, caulking compounds, and enamel.

The largest use of tripoli is as a filler and extender in paints. These uses are estimated to account for as much as 85% of the tripoli used as filler and extender. Its use in exterior latex paints is as a low-micrometer grade micronized product. In these paints, tripoli aids in tint retention, durability, leveling, and flowability. In enamels, it permits higher loading with no appreciable increase in vehicle demand and improves sheen. Because of its controlled grain or particle size, paints containing tripoli disperse easier and result in an uniform film. Additionally, because of its abrasive qualities the paints are more resistive to wear, and more resistive to chemicals than those in which water-ground whitings and other reactive fillers are used.

Plastics, rubbers, and resins each use about 5% of total annual tripoli filler and extender production. It is used extensively in plastics for electrical uses because of its dielectric properties and its affects on flexural and compressive strengths. Its chemical resistance, weatherability, and resistance to salt spray also are important to its use in plastics. Its physical properties allow high loading in most compounds, but its abrasiveness results in high wear in extruding nozzles and molds. The same properties that makes tripoli useful as a filler and extender in plastics makes it valuable to the rubber and resin industries.

Tripoli contains essentially 100% crystalline silica, so its use can cause silicosis and falls under the jurisdiction of the Occupational Safety and Health Administration's (OSHA) Hazard Communication Standard. The International Agency for Research on Cancer and other independent studies have determined that crystalline silica is a probable carcinogen for humans. As a result, OSHA is required to regulate materials containing more than 0.1% crystalline silica. To date, it does not appear that these regulations have adversely affected the use of tripoli, but all tripoli must be labeled in compliance with OSHA regulations.

Price.—The average reported value of abrasive tripoli, sold or used, in the United States was about $133 per ton. This was a 13% decrease in the average value after 11 years of continuous increases. The average reported value of filler tripoli, sold or used, in the United States was $132 per ton. This was a 38% decrease after 11 consecutive years of increases in the average reported value.

Special Silica Stone

Special silica stone products include hones, whetstones, oilstones, stone files, grindstones, grinding pebbles, tube-mill liners, deburring media, and certain specialty products. These do not include products made from artificially bonded abrasive grains. Manufacture of these products was from novaculite, quartzite, or other quarried microcrystalline quartz rock.

Production.—Plants manufactured oilstones, hones, whetstones, and files in Arkansas. Additional production includes grindstones in Ohio, deburring media in Arkansas and Wisconsin, and grinding pebbles and mill liners in Minnesota. Production of the crude materials was in the same State as the products manufactured. *(See tables 2 and 3.)*

The industry manufactured four main grades of Arkansas whetstone. They ranged in grade from the high-quality Black Hard Arkansas Stone down to the Washita Stone. The Black Hard has a porosity of 0.07% and a waxy luster, while Washita Stone has a porosity of 16% and resembles unglazed porcelain.

Arkansas accounted for essentially 100%

of the value and total quantity of special silica stone products reported as sold or used by U.S. producers.

Consumption.—The domestic consumption of special silica stone products is a combination of residential, industrial, leisure, and craft uses. The major residential uses were the sharpening of knives and other cutlery such as scissors, shears, and lawn and garden tools. Major industrial uses were the sharpening and honing of cutting surfaces, polishing of metal surfaces, and the deburring of metal and plastic castings. The manufacture, repair, and modification of guns also make use of stone files. The recreational uses were the sharpening of sports knives, arrowheads, spear points, fish hooks, and other recreational items. Craft applications included uses in sharping tools for wood carving, gun engraving, jewelry making, and other engraving work.

Prices.—The value of crude novaculite suitable for cutting into finished products varied from $13 per ton to $895 per ton. The low value was for Washita grade and the high for Black Hard Arkansas grade. The manufacture of deburring media or special-purpose crushed stone is from material not suited for making oilstones, hones, or whetstones. The value of these materials ranged from $469 per ton to $1,176 per ton.

Foreign Trade.—The value of exported special silica stone products was $8.6 million, an increase of 30% compared with that of 1993.

The value of imported products was $2.4 million, the same as for 1993. The United States continues to be a net exporter of special silica stone products. A portion of the finished products imported was from crude novaculite produced within the United States and exported for processing. In 1994, the trade surplus in special silica stone products was $6.2 million, an increase of about 29%.

Outlook

The use patterns for tripoli and special silica stone will not change significantly in the next 5 years. Most of the markets are well defined and the chance of developing new markets are limited.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publication

Abrasive Materials Annual Report, 1993.

TABLE 1
PROCESSED TRIPOLI 1/ 2/ SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE

Use		1990	1991	1992	1993	1994
Abrasives	metric tons	24,100	21,200	18,600	19,400	39,000
Value	thousands	$3,080	$3,380	$2,780	$2,960	$5,170
Filler	metric tons	56,500	52,300	57,600	58,900	42,800
Value	thousands	$11,000	$10,000	$11,300	$12,600	$5,640
Total quantity	metric tons	80,600	73,600	76,200	78,300	82,300
Total value	thousands	$14,100	$13,400	$14,100	$15,500	$10,900

1/ Includes amorphous silica and Pennsylvania rottenstone.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 2
SALIENT U.S. SPECIAL SILICA STONE STATISTICS 1/

	Crude production		Sold or used	
Year	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1990	3,710	$230	450	$6,330
1991	2,210	161	272	3,600
1992	1,730	239	340	4,550
1993	528	240	267	3,770
1994	W	242	514	W

W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digitis.

TABLE 3
U.S. PRODUCERS OF SPECIAL SILICA STONE PRODUCTS IN 1994

Company and location	Type of operation	Product
Arkansas Abrasives, Inc.:		
Hot Springs, AR	Stone cutting and finishing	Whetstones and oilstones.
Do.	Quarry	Crude novaculite.
Blue Mountain Whetstone Co.:		
Hot Srpings, AR	Stone cutting and finishing	Whetstones and oilstones.
Buffalo Stone Corp.:		
Hot Springs, AR	Tumbling and sizing novaculite	Metal finishing media deburring media.
Cleveland Quarries Co.:		
Amherst, OH	Stone cutting and finishing	Grindstones.
Do.	Quarry	Crude silica stone.
Gary Coleman:		
Jessieville, AR	do.	Crude novaculite.
Crow Stone Co.:		
Pearcy, AR	do.	Whetstones and oilstones.
Do.	do.	Crude novaculite.
Dan's Whetstone Co., Inc.:		
Hot Springs, AR	Stone cutting and finishing	Whetstones and oilstones.
Do.	Quarry	Crude novaculite.
Hall's Arkansas Oilstones, Inc.:		
Pearcy, AR	Stone cutting and finishing	Whetstones and oilstones.
Ed Kraemer and Sons Inc.:		
Baraboo, WI	Crushing and sizing	Deburring media.
Do.	Quarry	Crude silica stone.
Norton Company Oilstones:		
Hot Spring, AR	do.	Do.
Littleton, NH	Stone cutting and finishing	Whetstones and oilstones.
Robert Parker Stone Co.:		
Malvern, AR	Quarry	Crude novaculite.
Smith Abrasives, Inc.:		
Hot Springs, AR	Stone cutting and finishing	Whetstones and oilstones.
Do.	Quarry	Crude novaculite.
Taylor Made Crafts:		
Lake Hamilton, AR	Stone cutting and finishing	Whetstones and oilstones.

TUNGSTEN

By Earle B. Amey

Tungsten's unique high-temperature properties can be utilized advantageously in the production of numerous end-use items. The high melting point, high density, good corrosion resistance, and good thermal and electrical conductivity properties of tungsten and its alloys and the excellent cutting and wear-resistant properties of its carbide continue to provide important items for consumption in the domestic and military sectors.

Total reported domestic consumption of tungsten in primary end-use categories increased by about 7% in 1994 compared with that of 1993. Demand generally increased in the cemented carbide end-use sectors that included the combined cutting tool, mining tool, oil drilling equipment, and wear-resistant component industries. Demand for tungsten chemicals and directly reusable tungsten scrap also increased in 1994. Counter to these increases was a decrease in the use of ferrotungsten in steels, which included the tool, alloy, and stainless steel sectors as well as a decrease in the demand for mill products made from metal powder. A gradual strengthening of the U.S. economy influenced the overall increase in demand for tungsten products during 1994.

The average Metal Bulletin (London) combined price for wolframite and scheelite concentrates, instituted in April 1992, increased about 23% in 1994 compared with that of 1993. The concentrate price increased to an average of $42.35 per metric ton unit (mtu) tungsten oxide from an average of $34.56 per mtu in 1993. This trend for 1994 reversed the downward trend that existed since 1992.

Prices for ammonium paratungstate (APT) on the world market increased during 1994, consistent with the increasing prices for concentrates. According to quotations in Metal Bulletin (London), the average price for APT on the U.S. market, duty-paid and delivered to processing plants, increased by 67% from an average of $48.50 per mtu in January to an average of $81.00 per mtu by yearend. Similarly, quotations for Chinese No. 1 Grade APT in Hong Kong increased by 192% during the year from an average price of $29.50 per mtu to an average of $86.00 per mtu. The average price of APT on the European free market increased by 157%, from $35 per mtu to $90 per mtu, according to quotations published in Metal Bulletin (London).

As a result of a stronger tungsten market, at least one additional tungsten mine operator (none in the United States) was opened. The pattern of imports of tungsten materials by U.S. processors during 1994 showed a shift towards tungsten concentrate, tungsten oxide, tungsten scrap, and sodium tungstate and away from the intermediates ammonium paratungstate. Competition is apparently coming from the Russians. However, China continued to be the dominant supplier of tungsten materials to the United States in 1994, providing about 33% of all imported tungsten materials.

A summary of the important U.S. and international statistics for 1994 and the previous 4 years are shown in table 1. *(See table 1.)*

Legislation and Government Programs

The Office of the United States Trade Representative (USTR) investigated, under the Trade Act of 1974, acts, policies, and practices of the Government of China concerning the enforcement of intellectual property rights and the provision of property protection. If these acts, policies, and practices are to be unreasonable and constitute a burden or restriction on U.S. commerce, USTR will propose raising tariffs on a list of Chinese import articles. The antidumping tariffs on imports of tungsten ore concentrates and products from China, initially imposed on October 28, 1991, were extended until March 1995. These import duties are currently 37% on tungsten concentrates, 35% on tungsten oxide and acid, and 33% on tungsten carbide and fused carbide. The extent to which the tariffs might affect the European market is uncertain, primarily because ammonium paratungstate (APT), the major tungsten material being processed in Europe, is not included under these tariffs.

Three Republics in the former U.S.S.R. were granted Generalized System of Preferences (GSP) trade status. Documents signed by the President provided GSP status to Kazakhstan, Romania, and Ukraine effective in March. These Republics will be permitted to have its imports enter the U.S. duty free rather than be assessed the duty that exists under Most-Favored-Nation trade status. Tungsten affected by the GSP status includes concentrates, ferrotungsten, carbide powder blends, and certain forms of waste and scrap.

Strategic Considerations

Tungsten is an important strategic material necessary for defense purposes, including the industrial base. Currently, the heavy-metal alloys of tungsten, containing 3% to 10% nickel and small quantities of iron or copper, are used in several of the smaller diameter projectiles for penetrating armor plate. Cemented tungsten carbide parts, which exhibit excellent cutting and wear-resistant properties, are vital to the U.S. metalworking, machining, construction, transportation, mining, and oil and gas drilling industries. Tungsten mill products and powders are essential to the lamp and lighting industry as filaments and electrodes; to the electrical and electronic industries as wear-resistant, electrically conductive contact surfaces; and to the superalloy and steel industries as alloying components. The Department of Defense (DOD) relies heavily on the maintenance of a broad domestic production base to cover mobilization contingencies. The entire tungsten industry, from mined ore to manufactured products, thus represents an important component of the U.S. defense policy. The DOD continually assesses the U.S. ability to produce tungsten to ensure that this and other sources of supply are sufficient to meet current and projected levels of demand necessary to preserve the national defense.

Issues

During 1994, prices for tungsten concentrates strengthened reaching 1992 levels. Major liquidation of both Russian and Chinese stockpiles occurred as the supply of tungsten ore tightened and a large amount of tungsten ore was put into production. Because of the uncertainty of the tungsten market, however, Western mine operators continued to leave its mine on care-and-maintenance status, or to keep its mines closed.

China remained the principal supplier of tungsten products to the world market during 1994, and many observers believe that stocks of Chinese concentrate have nearly been depleted. On the other hand, the quantity of tungsten materials available from Russia and certain other members of the Commonwealth of Independent States (C.I.S.) began to become competitive with China. However, uncertainties still remain regarding the extent to which the C.I.S. might become a source of tungsten supply to the world market as it makes the transition to a market economy. Given all of these tungsten market factors, by yearend 1994 industry analysts believed a more balanced supply-demand condition was in place, but the future is very much dependent upon the Chinese.

Production

Domestic production data for tungsten are developed by the U.S. Bureau of Mines by means of two separate, voluntary surveys. These surveys are "Tungsten Ore and Concentrate" and "Tungsten Concentrate and Tungsten Products." Of the 15 mining and 14 processing operations to which survey requests were sent, response was received from 67% and 100%, respectively, of those operations surveyed. Production and stock totals for the survey respondents are shown in table 1.

Major processors of tungsten materials in 1994 were Buffalo Tungsten Inc., Depew, NY; General Electric Co., Euclid, OH; Osram Sylvania, Inc. (formerly GTE Products Corp.), Towanda, PA; Kennametal Inc., Latrobe, PA, and Fallon, NV; Teledyne Firth Sterling, LaVergne, TN; and Teledyne Advanced Materials (formerly Teledyne Wah Chang Huntsville), Huntsville, AL. Net production statistics for tungsten metal powders, carbides, and chemicals are shown in table 2. *(See table 2.)*

The already low tungsten mining activity in the United States further declined in 1994 as the uncertainties in the tungsten market continued. Only limited quantities of tungsten concentrate and ammonium paratungstate were produced by U.S. Tungsten Corp., a division of Strategic Minerals Corp., at its Pine Creek Mine and conversion facility in Bishop, CA.

General Electric Co. (GE) completely liquidated their Springer tungsten mine. The Winnemucca mine last operated in November 1982 and had been put on maintenance and care status.

Consumption

Total reported domestic consumption of tungsten in primary end-use categories (table 3) increased by about 7% in 1994 compared with that of 1993. Demand generally increased in the cemented carbide end-use sectors that included the combined cutting tool, mining tool, oil drilling equipment, and wear-resistant component industries. Demand for ferrotungsten used in steels that included the tool, alloy, and stainless steel sectors, as well as demand for tungsten chemicals, also increased in 1994. Counter to these increases was a decrease in the demand for mill products made from powders and directly reusable tungsten scrap. *(See table 3.)*

Reported consumption of obsolete tungsten scrap, reprocessed either chemically or physically for reuse, decreased to 2,073 metric tons of contained tungsten in 1994 from 2,156 tons in 1993. Increased competition associated with the uncertainty in the market for primary and intermediate tungsten materials likely contributed to the decline in demand for this form of scrap.

Further strengthening of the U.S. economy influenced the overall increase in demand for tungsten products during 1994. A slow economic recovery in the major industrial sectors of auto, aerospace, and construction, where a significant quantity of tungsten is consumed as cemented carbide components, continued from 1993. Demand for cemented carbide components in the oil drilling industry fluctuated during 1994. The number of operating oil drilling rigs in the United States rapidly declined from a high of 813 in early January to a yearly low of 697 rigs in late May, then gradually increased to yearly high of 842 rigs by yearend 1994, according to figures reported by the International Association of Drilling Contractors and Baker Hughes Inc.

Foreign Trade

Comprehensive lists of U.S. export and import trade statistics by material quantity and value and by country of destination and origin are shown in tables 5 through 13. *(See tables 5 through 13.)*

The pattern of imports of tungsten materials by U.S. processors during 1994 showed a shift away from the intermediate ammonium paratungstate and toward tungsten concentrate and the intermediates tungsten oxide and sodium tungstate. The shift reversed a trend that began in 1991, subsequent to the imposition of the 151% antidumping tariff on imports of concentrate from China that effectively halted such imports. The concentrate prices increased during this period with an increase in demand and the appearance of a depletion of Chinese inventories. In 1994, concentrate represented a 44% share of the combined imports of concentrate and intermediates from all sources, compared with a 36% share in 1993, a 63% share in 1992, and an 87% share in 1990, prior to the antidumping tariff. The share of these combined imports of concentrate and intermediate materials provided by China as intermediate materials was 37% in 1994 down from 51% in 1993.

Total U.S. imports of all tungsten materials increased by 43% in 1994 compared with those of 1993. China continued to be the dominant supplier, providing about 33% of all imported tungsten materials. China's share of the total quantity of tungsten materials imported by the United States was down about 11 percentage points compared with that of 1993. However, the total quantity of tungsten materials imported from China increased from 3,280 tons of contained tungsten in 1993 to 3,500 tons in 1994. Of the total tungsten imports from China in 1994, the percentage imported as intermediate products was 71%, about the same as 1993. Major suppliers of concentrates to the United States in 1994 included Russia (56%), Bolivia (18%), and Peru (10%).

World Review

Capacity.—Rated capacity for mines and mills as of December 31, 1994, was approximately 42,000 tons of contained tungsten. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure.

Mine capacity for tungsten is based on published reports, maximum production statistics, and estimates. The latter is utilized particularly for certain countries where capacity information is either incomplete or unavailable. Estimated annual mine production capacity declined by about 20% in 1994 compared with that of 1993. Some of this decline was attributed to an estimated lower capacity in the C.I.S., associated with the transition to a market economic system within the individual republics of the former U.S.S.R. Decline in mine capacity was attributed further to the apparent closure of additional smaller, inefficient mines in China, as well as to production declines at some larger mines, following the discontinuation of Government subsidies to tungsten mines during the last quarter of 1992.

Annual concentrate world production is shown by country in Table 14 and as a total in table 1; annual world concentrate consumption statistics are also shown in table 1. *(See tables 1 and 14.)*

Austria.—Metallgesellshaft (MG) put its shareholding in the Mittersill tungsten mine and the Wolfram Berbau and Huttengesellschaft conversion plant on the market. MG has a 67% shareholding, with Plansee Metall holding 26% and Teledyne 7%.

China.—According to published reports, the availability of tungsten materials from China became more limited. Many Chinese tungsten mines have closed down since 1991 as a result of low ore prices. China National Minerals and Metals Import and Export Corp. (Minmetals) ceased offering tungsten products, including ore concentrates, and the intermediate materials ammonium paratungstate (APT) and tungsten oxides, in late April 1994. A spokesperson for Minmetals indicated the action was necessary due to domestic shortages of tungsten ore and concentrates. As a result, day-to-day sales of some of the Chinese products are much more selective. Russian tungsten materials appear to be slowly entering the world market as an alternative source for consumers.

Commonwealth of Independent States.—During 1994, there were increased efforts by the republics of the former U.S.S.R to market a variety of tungsten-containing materials and products. Metallurgical operations that were formerly staffed and funded to meet the defense and aerospace requirements, as well as the domestic needs for mining and metalworking, were continuing plans to provide quality tungsten merchandise to the market. The merchandise expected to be marketed included tungsten oxide, metal and carbide powders, as well as a number of wrought shapes, such as rod, wire, tube, strip and foil, and certain end-use products, consisting of cemented carbide cutting tools, drill bits, and wear parts.

India.—Development of tungsten mining resources in India could be affected by privatization efforts underway in that country. India informed its mining policy in March 1993 to allow up to 50% foreign equity investment effective January 1994. Although Indian tungsten resources have not been fully delineated, an excess of 10 million tons of ore have been estimated with a metal content of about 50 thousand tons of tungsten.

International Tungsten Industry Association (ITIA).—The International Tungsten Industry Association (ITIA) held its seventh International Tungsten Symposium in Huntsville, Alabama (USA), November 2-4, 1994. Speakers from six countries presented a wide range of papers covering subjects, focusing on tungsten supply, demand, production, and consumption, as well as technological papers detailing developments in applications of high-purity tungsten and chemical vapor deposited tungsten, new developments in indexable metal cutting inserts, and a review of hardmetals and tungsten heavy alloys markets. One of the highlights was provided by the Chinese delegation's presentation on various aspects of production and consumption in China. The paper stated that, in an effort to play a positive role in the world's tungsten market, the Chinese government had imposed new taxes and a strict export quota and licensing system.

Korea, Republic of.—The government of the Republic of Korea, consistent with its ongoing privatization process, sold its majority ownership in Korea Tungsten Mining Co. Ltd. (KTMC). The new owner, Keopyung Group, a Korean conglomerate, will continue to maintain KTMC's Sangdong Tungsten Mine on care and maintenance status.

Japan.—Japan reportedly closed its last tungsten mine in September 1993. The mine, in Yamaguchi prefecture and owned by Tanaka Kogyo, supplied a portion of Japan's demand for tungsten, but for most of 1993 it operated well below capacity. Falling market prices for the intermediate tungstates made it more economical and practical to import additional quantities of the intermediates, mainly from China, than to domestically produce and process the concentrate.

Peru.—Avocet Ventures Inc., B.C., Canada, parent company of Waller Metals Ltd., London, U.K., purchased an additional tungsten mining interest in Peru. Fermin Malaga Santolalla e Hijos Negociacion Minera S.A., Peruvian owner and operator of the Pasto Bueno Mine, sold 40% of the mine's shares to Avocet. The Pasto Bueno Mine, located in the Pampas District of the Pallasca Province in Ancash Department, near Lima, had been operated on a limited basis in recent years because of low tungsten prices. Fermin Malaga is, with the assistance of Avocet, developing plans to bring production and milling to its rated capacity of 1,200 tons of tungsten per year. Avocet also holds a 20% interest in Peru's Minera Regina, owner of the Palaca XI tungsten mine, with an option to increase the equity interest to 41%. The mine started production in January and has been increasing output of tungsten concentrates primarily to fulfill its long-term contract with Osram (USA).

Portugal.—Avocet Ventures Inc., B.C., Canada, parent company of Waller Metals Ltd., London, U.K., announced plans to reopen the Panasquiera tungsten mine near Fundao in January 1995. Minorco SA, Luxembourg, the company from whom Avocet purchased the mine in early 1994, had placed it on care and maintenance status at the end of 1993. According to a spokesperson for the new ownership of the Panasquiera Mine, a strengthening of the tungsten market was foreseen.

Russia.—According to published reports, Russia, a former trade recipient of Chinese tungsten materials, shipped several tons of tungsten concentrates into China. China is reported to be converting the Russian concentrates into ammonium paratungstate for export as a means of circumventing Chinese import restrictions on tungsten concentrates.

Sandvik AB, Sandviken, Sweden, a leading manufacturer of cemented tungsten carbide products, acquired more than 50% interest in a major Russian carbide manufacturing company. The Russian company, Moskovoskji Kombinat Tverdih Splavov (MKTS), manufactures and markets cemented carbide components for use as machine tools, rock-drilling tips and wear parts. Sandvik has had a 20-year association with MKTS and began to acquire shares in the company when MKST initiated a move to privatize in 1993. According to a spokesperson for Sandvik, the acquisition was an important step towards creating a base for supplying the Russian industry with cemented carbide products as gains are made in the Russian economy.

United Nations Conference on Trade and Development (UNCTAD).—The third Meeting of the UNCTAD Intergovernmental Group of Experts on Tungsten (IGE) was held in Geneva, Switzerland, November 7-9, 1994. The Secretariat from the UNCTAD, as well as individual delegations, provided a positive outlook for the world tungsten industry, but also outlined several issues that confronted the international tungsten industry. Possibly significant is the emergence of The Russian Federation as a supplier of a broad range of tungsten products, Kazakhstan as a possible supplier of ore and concentrate, and the erratic relationship between ore and concentrate prices versus the prices for intermediate tungsten prices. Most importantly, however, was the lack of participation from China and their unsatisfactory quality and level of participation in reporting statistics to the Secretariat.

The Secretariat requested to continue statistical data collection and dissemination, as well as review of the tungsten market, an essential ingredient for continued market transparency. This objective has eluded IGE because significant market participants, such as China, do not participate in data collection. As a result, IGE decided to remit to the fourth session of the Standing Committee on Commodities the determination of a date for the fourth session of the IGE on tungsten.

The Director of Marketing for the Metal Powder Industry Federation in Princeton, New Jersey, an industry advisor to the U.S. delegation, presented a paper entitled, "U.S. Tungsten Demand Grows in Face of Shrinking Raw Materials Base". He stated that U.S. producers are enjoying good business, but are concerned regarding the availability of ore, concentrates, and intermediate products for the near and longterm.

Current Research and Technology

GE Lighting, a division of General Electric Co., Fairfield, Conn., introduced in Europe a new energy-saving lamp without a tungsten filament that instead uses a high-frequency magnetic field to produce light. The lamp will be introduced first to industrial consumers. It consumes only 23 watts to produce light similar to a 100-watt incandescent reflector lamp and still fits into existing sockets. In addition, the new "induction" reflector light bulb lasts about 10 times longer. Each year about 384,000 pounds of tungsten are sold in the United States to make filaments for light bulbs.[1]

Tungsten, rhenium, and molybdenum wires have reportedly been laminated between sheets of niobium by means of explosive welding processes developed by Northwest Technical Industries in order to produce composites with high strength at high temperatures. The time duration required for explosive welding is so short that the heat-affected zone between the constituent materials is microscopic. Therefore, the initial physical and mechanical properties of the alloys are not degraded. These composites are being developed for the next generation of gas turbine and rocket engines.[2]

A new technique, which can create new metallurgical powder combinations, can also plate materials less expensively. This technique, called Self-Propagated High-temperature Synthesis (SPHTS), does not require as high a temperature nor the special equipment as previous methods. The technique can be used commercially to coat cutting tools or milling machines, and can be used to create incredible metallurgical powder combinations that have up to 20 times better adhesion. In addition, SPHTS can increase the hardness, as well as, life and usefulness of the hard alloy and ceramic tools.[3]

Tungsten carbide is being used in a punch to push out fibers in metal, ceramic, and polymer matrix composites. This fiber push-out apparatus can, at the same time, measure the fiber-matrix bond strength and sliding stress. These critical parameters can influence a composite's strength, fatigue, crack growth, and creep behavior. As a result, the apparatus has been used to examine failure modes in composite fibers with multiple coating layers, to study the effects of variables in hot isostatic pressing, and to investigate the effects of fiber distribution on interfacial properties.[4]

Military researchers are focusing on replacing depleted uranium (DU) in penetrators, piercing tanks, and armor with heavy tungsten alloys. DU retains some radioactivity and is difficult to clean up. Currently, a DU penetrator makes a narrower hole and deeper penetration than would its tungsten-bearing counterpart. Researchers are working on these property differences and expect that the most likely replacement would be alloys containing combinations of tungsten, nickel, iron, and cobalt.[5]

Outlook

Based on the first quarter reported consumption of all tungsten products, the total annual demand for tungsten materials in the United States in 1995 was estimated to be about 9,000 tons of contained tungsten. This would represent an increase in consumption of approximately 10% compared with the 8,112 tons reported for 1994. The economic recovery rate in 1995 is expected to exceed slightly the modest gains the economy experienced in 1994. As a result, overall demand for cutting and wear-resistant components integrally associated with the metalworking, machining, construction, transportation, mining, and oil and gas drilling industries is expected to increase moderately in 1995. In particular, the consumption of cemented carbide tool bit inserts is expected to increase as the automobile market grows and the requirement for machined automobile parts correspondingly rises. In the short term, demand for tungsten in the lighting, electrical, and electronic sectors is expected to continue to increase slowly, although there could be a significant erosion of this demand should the recent breakthroughs in the development of tungsten-free light bulbs begin to capture a significant portion of the lighting market. The general rate of growth in tungsten demand will continue to be dampened by the effects of substitution in the cutting and wear-resistant component industries as well as by technological improvements within the industry that result in a more efficient use of tungsten.

The sources of future supplies of tungsten concentrate and intermediate materials for U.S. consumption became less certain by the end of 1994 as observers indicated that some clearing of inventories by traders had taken place. Specifically, the future supply of ammonium paratungstate from China, the predominate world provider, remained questionable in view of the continued low mine production that was limiting the quantity of concentrate production. In addition, China was believed to have exhausted its supply of concentrate stocks. Consequently, a more balanced tungsten supply-demand condition began to emerge at the end of 1994. In the short term, the tungsten market was expected to correct the transition from an oversupply of tungsten to one that more closely balances its supply and demand, effectively allowing for the entrance of more producers into the market.

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[2] Butler, D. Refractory Metal Composites Laminated by Explosive Bonding. Advanced Materials & Processing. V. 146, No. 4, Oct. 1994, p. 7.

[3] American Metal Market. Powder Technology Applied to Plating. V. 102, No. 101, June 1994, p. 5.

[4] Touchstone Research Laboratory. Fiber-Matrix Bond Strength and Sliding Stress Measured. Advanced Materials & Processes. V. 145, No. 2, Feb. 1994, p. 14.

[5] American Metal Market. Tungsten Understudy for Armor-Piercing Role. V. 102, No. 208, Oct. 1994, p. 5.

[6] New Coatings and Surfaces. Deposition of Tungsten Films With Controlled Structure. Nov. 1993, p. 2.

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TABLE 1
SALIENT TUNGSTEN STATISTICS 1/

(Metric tons of tungsten content unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Concentrate:					
Mine production	W	W	W	W	W
Mine shipments	W	W	W	W	W
Value thousands	W	W	W	W	W
Consumption	5,880 2/	5,310 2/	4,310	2,870 3/	3,630 3/
Shipments from Government stocks	--	--	--	--	--
Exports	139	21	38	63	44
Imports for consumption	6,420	7,840	2,480	1,720	2,960
Stocks, Dec. 31:					
Producer	16	26	44	44	44
Consumer	1,080	1,780	702	592	756
Ammonium paratungstate:					
Production	6,330 2/	5,860 2/	5,760	4,730 2/	536 4/
Consumption	8,790	8,900 5/	7,010	6,970	7,080
Stocks, Dec. 31: Producer and consumer	896	578	333	420	82
Primary products:					
Net production	4,680 6/	8,980	8,450	9,410	7,410
Consumption	8,500	7,980	6,910	7,580	8,110
Stocks, Dec. 31:					
Producer	1,460 7/	1,670 7/	1,510 7/	1,480 7/	1,160 7/
Consumer	793	796	601	716	849
World:					
Concentrate:					
Production	51,900 r/	48,200 r/	40,400 r/	32,000 r/	25,500 e/
Consumption 8/	45,300	41,900 r/	38,500 r/	31,800 r/	29,800 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Excludes 2 months of "Withheld" data.

3/ Excludes 3 months of "Withheld" data.

4/ Excludes 11 months of "Withheld" data.

5/ Excludes 1 month of "Withheld" data.

6/ Includes only hydrogen-reduced metal powder and chemicals.

7/ Excludes tungsten carbide-cast and crystalline.

8/ Based on data received from United Nations Conference on Trade and Development, Apr. 1995.

TABLE 2
NET PRODUCTION 1/ AND STOCKS OF TUNGSTEN PRODUCTS IN THE UNITED STATES 2/

(Metric tons of tungsten content)

	Hydrogen reduced metal powder	Tungsten carbide powder		Chemicals	Total
		Made from metal powder	Cast and crystalline		
Net production 1994	3,190	4,220	W	W	7,410
Net production 1993	4,660	4,750	W	W	9,410
Producer stocks, Dec. 31, 1994	648	390	W	120	1,160
Producer stocks, Dec. 31, 1993	816	519	W	147	1,480

W Withheld to avoid disclosing company proprietary data.

1/ Gross production less quantity used to make other products in table.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

TABLE 3
REPORTED CONSUMPTION AND STOCKS OF TUNGSTEN PRODUCTS IN THE UNITED STATES IN 1994, BY END USE 1/

(Metric tons of tungsten content)

End Use	Ferro-tungsten 2/	Tungsten metal powder	Tungsten carbide powder	Tungsten scrap 3/	Other tungsten materials 4/	Total
Steel:						
Stainless and heat-resisting	30	--	--	5	--	20
Alloy	18	--	--	--	--	19
Tool	529	--	--	W	W	529
Superalloys	W	W	33	199	W	300
Alloys (excludes steels and superalloys):						
Cutting and wear-resistant materials	--	97	5,640	W	W	5,920
Other alloys 5/	W	W	--	W	--	W
Mill products made from metal powder	--	1,200	--	--	--	1,200
Chemical and ceramic uses	--	W	(6/)	--	105	108
Miscellaneous and unspecified	--	--	--	--	W	W
Total	582	1,330	5,670 7/	388	141	8,110
Consumer stocks, Dec. 31, 1994	20	22	767 7/	40	(8/)	849

W Withheld to avoid disclosing company proprietary data; included in "Totals."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes scheelite, natural and synthetic.

3/ Does not include that used in making primary tungsten products.

4/ Includes tungsten chemicals and others.

5/ Includes welding and hard-facing rods and materials and nonferrous alloys.

6/ Included in "Tungsten carbide powder: Cutting and wear-resistant materials."

7/ Based on reported consumption plus information from secondary sources on companies not canvassed; includes estimates.

8/ Included in "Tungsten scrap."

TABLE 4
MONTHLY PRICE QUOTATIONS OF TUNGSTEN CONCENTRATE IN 1994

Month	Metal Bulletin (London), European market, 65% WO3 basis, c.i.f. 1/				Metals Week, U.S. spot quotations, 65% WO3 basis, c.i.f. U.S. ports, including duty 2/			
	Dollars per metric ton unit			Dollars per short ton unit	Dollars per short ton unit			Dollars per metric ton unit
	Low	High	Average	Average	Low	High	Average	Average
January	27.00	39.00	33.00	29.94	28.00	40.00	34.00	37.48
February	27.00	39.00	33.00	29.94	28.00	45.00	37.00	40.79
March	28.00	43.00	36.06	37.71	35.00	45.00	40.00	44.10
April	33.00	45.00	39.00	35.38	35.00	45.00	40.00	44.10
May	33.00	45.00	39.00	35.38	35.00	45.00	40.00	44.10
June	35.00	47.00	40.89	37.09	35.00	47.00	40.40	44.53
July	37.00	47.00	42.00	38.10	37.00	48.00	43.50	47.95
August	37.00	47.00	42.00	38.10	40.00	48.00	44.00	48.50
September	37.00	53.00	46.33	42.03	40.00	48.00	44.00	48.50
October	45.00	55.00	50.00	45.36	40.00	48.00	44.00	48.50
November	45.00	60.00	52.50	47.63	40.00	48.00	44.00	48.50
December	47.00	60.00	54.63	49.56	40.00	48.00	44.00	48.50

1/ Combined wolframite and scheelite quotations. Low and high prices are reported semiweekly. Monthly averages are arithmetic averages of semiweekly low and high prices. The average annual price per metric ton unit of W03, of all semiweekly low and high prices was $42.35 for 1994. The average equivalent price per short ton unit of W03 was $38.42 for 1994.

2/ Low and high prices are reported weekly. Monthly averages are arithmetic averages of weekly low and high prices. The average annual price per short ton unit of W03, of all weekly low and high prices was $41.22 for 1994. The average equivalent price per metric ton unit of WO3 was $45.43 for 1994.

TABLE 5
U.S. EXPORTS OF TUNGSTEN ORE AND CONCENTRATE, BY COUNTRY

Country	1993		1994	
	Tungsten content 1/ (metric tons)	Value (thousands)	Tungsten content 2/ (metric tons)	Value (thousands)
Canada	3	$14	--	--
France	1	3	--	--
India	1	6	--	--
Japan	--	--	41	$195
Korea, Republic of	1	3	--	--
Mexico	2	8	3	14
Netherlands	55	269	--	--
South Africa, Republic of	1	4	--	--
Taiwan	1	3	--	--
Total	63	309	44	209

1/ Calculated based upon an estimated value of $39 per metric ton unit WO3.

2/ Calculated based upon an estimated value of $38 per metric ton unit WO3.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF AMMONIUM PARATUNGSTATE, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Belgium	--	--	54	$1,110
Germany	2	$28	91	303
Japan	164	2,180	35	175
Netherlands	--	--	70	614
Total	166	2,210	250	2,200

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
U.S. EXPORTS OF TUNGSTEN CARBIDE POWDER, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Argentina	2	$45	(2/)	$22
Australia	8	435	7	229
Austria	27	366	55	920
Belgium	11	227	3	132
Brazil	8	168	16	197
Canada	373	7,870	411	9,550
Chile	--	--	(2/)	22
China	--	--	6	38
Denmark	169	1,120	65	442
Finland	1	81	2	48
France	14	208	92	1,250
Germany	226	3,270	135	2,570
India	(2/)	4	(2/)	13
Ireland	4	191	--	--
Israel	4	389	10	673
Italy	58	1,910	89	2,930
Japan	83	1,120	42	973
Korea, Republic of	1	54	2	235
Luxembourg	3	54	3	102
Mexico	2	124	1	112
Netherlands	52	716	99	1,340
Portugal	--	--	5	44
Singapore	5	192	3	185
South Africa, Republic of	14	162	13	212
Spain	--	--	1	16
Sweden	84	1,200	106	2,120
Switzerland	12	742	22	853
Taiwan	4	181	18	496
United Kingdom	78	1,500	108	1,690
Venezuela	3	100	4	131
Other	2	59	1	95
Total	1,250	22,500	1,320	27,600

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 8
U.S. EXPORTS OF TUNGSTEN AND TUNGSTEN ALLOY POWDER, BY COUNTRY 1/

Country	1993			1994		
	Gross weight (metric tons)	Tungsten content 2/ (metric tons)	Value (thou- sands)	Gross weight (metric tons)	Tungsten content 2/ (metric tons)	Value (thou- sands)
Australia	7	6	$63	4	3	$66
Austria	5	4	73	1	1	29
Belgium	1	1	24	3	2	93
Brazil	17	14	17	7	6	222
Canada	36	29	792	43	34	930
Finland	1	1	28	2	2	54
France	1	1	66	11	9	344
Germany	104	83	2,460	207	166	5,910
Hong Kong	2	2	36	1	1	30
Israel	121	97	807	152	122	1,380
Italy	6	5	252	3	2	111
Japan	9	7	198	4	3	122
Korea, Republic of	1	1	29	1	1	64
Mexico	5	4	115	18	14	216
Netherlands	81	65	661	2	2	38
Singapore	32	26	455	53	42	806
South Africa, Republic of	1	1	18	2	2	56
Spain	(3/)	(3/)	7	--	--	--
Sweden	23	18	23	21	17	314
Switzerland	5	4	123	17	14	271
Taiwan	23	18	653	15	12	389
Turkey	1	1	16	(3/)	(3/)	4
United Kingdom	34	27	926	25	20	1,010
Other	1	1	21	2	2	87
Total	516	416	7,860	595	477	12,500

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Tungsten content estimated by multiplying gross weight by 0.80.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 9
U.S. EXPORTS OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS 1/

Product and country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Tungsten and tungsten alloy wire:				
Argentina	1	$6	--	--
Belgium	--	--	1	$59
Brazil	4	247	(2/)	60
Canada	5	368	4	201
China	1	102	4	518
France	(2/)	51	(2/)	54
Germany	3	189	(2/)	70
Hong Kong	1	99	2	158
India	17	1,030	10	626
Italy	1	166	(2/)	26
Japan	7	898	3	421
Korea, Republic of	3	170	1	67
Mexico	4	230	4	330
Netherlands	(2/)	17	(2/)	28
Poland	(2/)	11	(2/)	3
Switzerland	(2/)	6	(2/)	3
Taiwan	8	440	5	395
United Kingdom	1	150	2	197
Other	9	642	4	316
Total	65	4,830	40	3,530
Unwrought tungsten and alloy in crude form, waste and scrap:				
Australia	32	284	106	527
Belgium	(2/)	4	--	--
Canada	11	189	70	546
Chile	4	61	1	6
France	--	--	2	11
Germany	144	1,270	256	1,170
Israel	3	39	1	10
Italy	--	--	23	182
Japan	--	--	7	37
Mexico	17	365	63	354
Spain	10	62	15	83
Sweden	5	42	12	100
Taiwan	2	732	3	42
United Kingdom	28	150	25	154
Other	7	63	49	252
Total	263	3,260	633	3,470
Other tungsten metal:				
Australia	2	165	1	61
Belgium	(2/)	7	(2/)	68
Brazil	2	251	2	238
Canada	9	437	4	256
Colombia	1	221	(2/)	31
France	1	314	2	330
Germany	6	445	2	213
Hong Kong	4	699	4	783
India	2	119	2	92
Ireland	1	69	(2/)	103
Italy	2	134	1	645
Japan	6	1,950	8	1,360
Korea, Republic of	2	139	3	258
Mexico	8	818	4	455
Netherlands	(2/)	124	(2/)	192
Singapore	2	432	2	601
South Africa, Republic of	1	81	1	102
Sweden	(2/)	12	(2/)	39
Switzerland	(2/)	120	(2/)	98
Taiwan	9	784	3	236
Thailand	1	65	(2/)	31
United Kingdom	10	722	14	859
Venezuela	(2/)	56	(2/)	61
Other	3	350	4	833
Total	70	8,510	55	7,950

See footnotes at end of table.

TABLE 9-Continued
U.S. EXPORTS OF MISCELLANEOUS TUNGSTEN-BEARING MATERAILS 1/

Product and country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Ferrotungsten and ferrosilicon tungsten:				
Canada	1	$8	1	$13
Germany	--	--	31	50
Mexico	--	--	7	8
Total	1	8	39	71
Wrought tungsten:				
Canada	40	1,260	58	1,820
France	6	379	9	693
Germany	5	181	24	680
India	8	424	11	569
Israel	10	147	1	124
Italy	4	283	8	566
Japan	12	1,110	8	977
Korea, Republic of	7	598	18	881
Mexico	1	78	4	181
Netherlands	(2/)	39	(2/)	136
Saudi Arabia	19	1,490	--	--
Singapore	2	67	1	50
Spain	6	220	7	319
Taiwan	1	223	3	382
United Kingdom	6	391	3	328
Venezuela	1	21	--	--
Other	3	299	6	531
Total	131	7,220	161	8,230
Other tungsten compounds: 3/				
Argentina	--	--	(2/)	7
Brazil	11	152	37	292
Canada	6	22	3	9
Colombia	(2/)	3	1	8
Japan	--	--	17	56
Netherlands	--	--	49	236
Sweden	--	--	36	100
United Kingdom	3	36	6	54
Other	--	--	1	43
Total	20	213	150	804

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Includes only other tungstates.

Source: Bureau of the Census.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF TUNGSTEN ORE AND CONCENTRATE, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thou-sands)	Tungsten content (metric tons)	Value (thou-sands)
Australia	--	--	74	$507
Bolivia	762	$3,390	542	2,090
Brazil	--	--	76	342
Burma	55	245	11	64
Chile	--	--	27	107
Japan	31	142	--	--
Korea, Republic of	--	--	14	68
Mexico	48	137	58	269
Netherlands	47	161	--	--
Peru	299	1,450	306	1,280
Portugal	240	1,550	--	--
Russia	1	4	1,660	3,600
Rwanda	132	399	--	--
Thailand	34	168	126	587
Uganda	73	195	57	130
Vietnam	--	--	11	63
Total	1,720	7,840	2,960	9,110

1/Previously published and 1994 data are rounded by the U.S. Bureau of MInes to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM PARATUNGSTATE, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thou-sands)	Tungsten content (metric tons)	Value (thou-sands)
China	934	$5,080	625	$3,240
Germany	109	1,000	160	1,590
Hong Kong	115	346	45	249
Japan	(2/)	12	--	--
Russia	--	--	18	140
Sweden	17	39	--	--
Total	1,180	6,480	848	5,220

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF FERROTUNGSTEN, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thou-sands)	Tungsten content (metric tons)	Value (thou-sands)
Austria	27	$152	--	--
China	516	2,220	484	$1,720
France	1	3	--	--
Germany	(2/)	5	--	--
Hong Kong	78	285	--	--
Mexico	31	161	31	161
Total	652	2,830	515	1,880

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS 1/

Product and country	1993 Tungsten content (metric tons)	1993 Value (thousands)	1994 Tungsten content (metric tons)	1994 Value (thousands)
Waste and scrap:				
Australia	1	$2	--	--
Austria	19	90	--	--
Belgium	4	30	115	$511
Brazil	31	154	18	75
Canada	6	28	20	80
China	74	408	159	1,000
France	23	89	102	367
Germany	241	1,090	531	2,580
Ireland	46	276	32	168
Israel	85	254	80	211
Italy	41	161	129	401
Japan	197	1,110	401	1,600
Korea, Republic of	8	48	20	47
Mexico	1	5	5	22
Netherlands	36	250	31	220
Pakistan	75	132	18	34
Portugal	13	66	6	28
Russia	10	60	132	858
Singapore	41	133	36	142
South Africa, Republic of	61	277	76	334
United Kingdom	235	889	561	1,910
Other	1	6	127	474
Total	1,250	5,560	2,600	11,100
Unwrought tungsten, except alloys, in lumps, grains, and powders:				
Belgium	2	104	3	110
Canada	12	369	11	389
China	-	--	61	691
Germany	17	745	24	871
Hungary	10	55	--	--
Japan	14	1,170	12	1,280
Russia	4	17	--	--
South Africa, Republic of	1	23	27	108
Uganda	--	--	13	20
United Kingdom	30	322	34	207
Other	5	131	14	142
Total	95	2,930	199	3,820
Unwrought tungsten, ingots, shot, alloy, and other:				
Austria	(2/)	19	2	164
China	(2/)	2	--	--
Germany	6	234	--	--
South Africa, Republic of	120	61	10	15
Other	4	5	(2/)	12
Total	130	320	12	190
Wrought tungsten-wire, plate, sheet, strip, foil, and other: 3/				
Austria	15	1,700	(2/)	52
Belgium	1	397	1	156
Canada	--	--	5	379
China	10	581	6	369
France	(2/)	122	(2/)	106
Germany	6	905	4	680
Israel	27	1,410	14	671
Japan	76	10,700	54	7,370
Mexico	6	1,190	(2/)	236
Netherlands	5	593	(2/)	375
Russia	(2/)	10	(2/)	4
United Kingdom	3	322	5	466
Other	8	570	14	1,210
Total	158	18,500	104	12,100

See footnotes at end of table.

TABLE 13-Continued
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS 1/

Product and country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Calcium tungstate:				
Bolivia	--	--	10	$45
China	158	$531	254	927
Germany	3	176	2	106
Japan	(2/)	17	(2/)	28
Total	161	723	267	1,110
Tungsten oxides:				
Austria	--	--	59	338
China	1,090 4/	5,060	890	4,470
Germany	234 4/	737	2	43
Hong Kong	44 4/	188	52	368
Russia	38 4/	315	929	5,140
Switzerland	--	--	43	164
United Kingdom	(2/) 4/	61	5	34
Other	(2/)	5	1	6
Total	1,400	6,370	1,980	10,600
Other metal-bearing materials in chief value of tungsten:				
China	4	101	--	--
Germany	--	--	(2/)	5
Total	4	101	(2/)	5
Chlorides of tungsten:				
China	41 4/	192	--	--
Other	(2/)	12	--	--
Total	41	204	--	--
Sodium tungstate:				
Bolivia	--	--	3	12
China	405	1,590	991	4,330
Germany	24	105	(2/)	39
Hong Kong	--	--	--	--
Japan	(2/)	29	(2/)	14
Zambia	(2/)	2	--	--
Total	429	1,730	994	4,390
Tungsten carbide:				
Austria	57	761	(2/)	12
Canada	31	833	10	369
China	53	1,050	30	919
France	3	63	24	349
Germany	99	1,690	159	2,790
Hong Kong	3	41	5	73
Israel	--	--	8	107
Japan	1	303	2	91
Korea, Republic of	17	318	17	252
Mexico	9	344	--	--
Sweden	13	364	--	--
United Kingdom	3	60	(2/)	2
Other	3	65	4	119
Total	291	5,890	258	5,080

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Quantity estimated from reported gross weight.

4/ All or part of these data have been referred to the Bureau of the Census for verification.

Source: Bureau of the Census.

TABLE 14
TUNGSTEN: WORLD CONCENTRATE PRODUCTION, BY COUNTRY1/ 2/

(Metric tons of tungsten content)

Country	1990	1991	1992	1993	1994e/
Argentina	6	5 r/	– r/	– r/	–
Australia	1,090	237	159 r/	23 r/	11
Austria	1,380	1,310	1,490 r/	104 r/	–
Bolivia	1,010	1,070	851	262 r/	450
Brazil	316	223	205	245 r/	250
Burma 3/	443 r/	356 r/	531 r/	524 r/	580
China e/ 4/	32,000	31,800	25,000	21,600 r/	16,500
Czechoslovakia e/ 5/	84	13	XX	XX	XX
India	10 e/	11	11	1 r/	1
Japan	260	279	347	66 r/	– 6/
Kazakhstan e/	XX	XX	200 r/	150 r/	100
Korea, North e/	1,000	1,000	1,000	1,000	900
Korea, Republic of	1,360	780	247	200	–
Malaysia	–	2	3	2	– 6/
Mexico	183	194	162	160 e/	150
Mongolia e/	500	300	260	250	250
Peru	1,540	1,230	802	398 r/	800
Portugal e/	1,410 r/	971 r/	1,870 r/	1,280 r/ e/	1,000
Russia e/	XX	XX	6,500 r/	5,000 r/	4,000
Rwanda e/	156 7/	175	175	175	30
Spain	10	–	–	–	–
Tajikistan e/	XX	XX	200	150	100
Thailand	290	230	70	18 r/ e/	20
Uganda e/	4	4	66 6/	60	60
U.S.S.R. e/ 8/	8,800	8,000	XX	XX	XX
United Kingdom	42	9	– r/	– r/	–
United States	W	W	W	W	W
Uzbekistan e/	XX	XX	300	300	300
Zaire	17	15 e/	–	–	–
Zimbabwe e/	1	1	–	–	–
Total	51,900 r/	48,200 r/	40,400 r/	32,000 r/	25,500

e/ Estimated. r/ Revised. W Witheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 5, 1995.

3/ Includes content of tin-tungsten concentrate.

4/ Based upon data published in the Yearbook of Nonferrous Metals Industry of China, 1992 and 1993.

5/ Dissolved Dec. 31, 1992.

6/ Reported figure.

7/ Estimate based on reported gross weight with a content of 54% W and 68% WO3.

8/ Dissolved in Dec. 1991.

VANADIUM

By Henry E. Hilliard

Vanadium, when present in small amounts in certain ferrous alloys, can significantly improve their properties. Manufacturers of automobiles and machinery recognized the toughness and fatigue resistance of vanadium alloys as far back as the early 1900's, incorporating the alloys in axles, crankshafts, gears, and other critical components. Vanadium has been used together with aluminum to give the required strength in titanium alloys used in jet engines and high-speed airframes. Vanadium improves the properties of alloys by reacting with carbon and nitrogen to form refractory carbides and carbonitrides, which act as precipitation strengtheners and grain refiners.

In addition to its metallurgical uses, vanadium has a wide range of uses that include catalytic, ceramic, and electronic applications. The first use of vanadium as a catalyst was in the production of sulfuric acid by the contact process. This type of catalyst was introduced into the United States in 1926 and gradually replaced platinum. Vanadium replaced platinum because it is more resistant to poisoning, is inexpensive, and is relatively abundant when compared to platinum. Sulfuric acid, known since the Middle Ages, has been an important item of commerce for more than 200 years. The catalytic activity of vanadium oxides enables the controlled oxidation of naphthalene and oxylene to phthalic anhydride, and of butane and benzene to maleic anhydride. Both compounds are essential monomers in the production of polyesters and plastics.

Few U.S. vanadium producers would call it an outstanding year, but most were satisfied with the results of 1994. Prices began to rise in the fourth quarter, and most other indicators of industry health, such as sales and shipments, began to move upwards as well. After more than 4 years of decline during which the price of vanadium pentoxide and ferrovanadium fell more than 50% from their 1989 peak, the change was welcome by U.S. vanadium producers.

The gains came, for the most part not from stronger demand, but through cutting costs, increased productivity, and production curtailments in a market that had been in oversupply for more than 4 years. There were signs that the most recent recession was over and that the newly trim vanadium industry might find 1995 a better year than 1994.

Legislation and Government Programs

Importers of Russian ferrovanadium and nitrided vanadium into the United States faced preliminary antidumping duties following a U.S. Department of Commerce preliminary determination, announced on December 28, 1994. In accordance with the preliminary determination, the U.S. Customs Service was directed to suspend liquidation of all entries of ferrovanadium and nitrided vanadium from the Russian Federation that had entered, or been withdrawn from warehouses for consumption on or after January 4, 1995, the date the notice was published in the Federal Register. The Customs Service would require a cash deposit or posting of a bond equal to the amount by which the fair market value exceeds the U.S. price. A final determination was postponed until the 135th day after the publication of the notice in the Federal Register.[1]

The Defense Logistics Agency was authorized to sell vanadium pentoxide (V_2O_5) in fiscal year 1995. The Pentagon decided that V_2O_5 was no longer needed in the National Defense Stockpile (NDS) and approved the sale of the entire stock. This will be the first vanadium sales from NDS since 1972. At yearend, the NDS contained 651 metric tons of V_2O_5.

Production

Vanadium pentoxide is the starting material for the production of most useful vanadium products. An exception is the direct production of ferrovanadium from vanadium-bearing iron slag by Shieldalloy Metallurgical Corp., at its plant in Cambridge, OH. In 1994 there were four active vanadium pentoxide mills in the United States: AMAX Metals Recovery Corp., Braithwaite, LA; Gulf Chemical and Metallurgical Corp., Freeport, TX; Kerr McGee Chemical Corp., Soda Springs, ID; and U.S. Vanadium Corp., Hot Springs, AR. U.S. Vanadium is a subsidiary of Strategic Minerals Corp., Danbury, CT, a totaly integrated vanadium producer. A fifth mill, Energy Fuels Nuclear, Inc. (formerly Umetco Minerals Corp.) Blanding, UT, was idle the entire year.

Domestic production data for vanadium were developed by the U.S. Bureau of Mines (USBM) from a voluntary survey of all U.S. operations. All five U.S. producers responded to the survey. In addition to the vanadium pentoxide mills, the Bureau canvassed three other companies which produce ferrovanadium, vanadium metal, vanadium chemicals, and other specialty vanadium alloys, e.g. aluminum-vanadium master alloys. These three companies also responded to the voluntary survey.

Production of vanadium pentoxide grew by 3% in 1994. Production grew by 9% in 1993 as well, after declining by about 18% in 1992. Production of downstream vanadium products varied widely, however. Production of ferrovanadium grew by 8%, whereas that for aluminum-vanadium master alloys increased by more than 20%. Preliminary data for the production of vanadium chemicals and catalysts indicate a moderate decrease in production. There was no domestic production of vanadium from primary ores in 1994. Raw materials included ferrophosphorous slag, spent catalyst, fly ash, and petroleum residues.

Consumption

Consumption data for vanadium were developed by the USBM from a voluntary survey of all known domestic consumers. There were 61 respondents to the 1994 survey, down from 83 in 1993. The 61 respondents represented 77% of the total canvassed and were estimated to have accounted for 90% of total consumption, or about 3,860 tons. The consumption of nonrespondents was estimated based on past consumption relationships, trends, and data from nonsurvey sources to be about 430 tons. The USBM estimate of total U.S. consumption of vanadium in 1994 was 4,290 tons as shown in table 1.

Metallurgical applications continued to dominate vanadium usage in 1994, accounting for more than 95% of total consumption. Nonmetallurgical applications included catalysts, ceramics, and vanadium chemicals. The USBM did not publish consumption figures for the nonmetallurgical end-use categories for 1994. However, the dominant nonmetallurgical use was in catalysts. Much less was consumed in ceramics and electronics. *(See table 4.)*

Prices

At yearend 1994, world vanadium supply and demand were in balance for the first time in more than 3 years. One large producer estimated world production of V_2O_5 in 1994 at 44,000 tons. The Republic of South Africa's (RSA) Minerals Bureau reported that about 52,600 tons of V_2O_5 were produced in 1993. The approximately 16% decrease in production mainly represented curtailments by producers in RSA and China, which effectively removed more than 5,000 tons of V_2O_5 from the world market. At the same time, steel production in the United States and the European Union increased in 1994; the price of molybdenum, for which vanadium may be substituted in some application, soared. As a result, vanadium prices firmed in the fourth quarter of 1994 and actually began to rise after more than 3 years of steady decline.

The domestic price, in first quarter 1994, of V_2O_5 was $1.35 to $1.40 per pound. By the end of December, the range was $4.25 to $5.00 per pound; the spot market price at the end of December 1994 ranged from $3.90 to $5.10 per pound. Ferrovanadium prices in 1994 were as follows (pounds/vanadium content): first quarter, $3.50 to $4.00; second quarter, $3.90 to $4.15; third quarter, $3.90 to $4.15; and fourth quarter, $4.15 to $7.95. Part of the price increase of ferrovanadium was caused by an increase in the price of aluminum, which increased from $0.50 per pound in January to $0.90 per pound in December. Aluminum is used as a reducing agent in the production of ferrovanadium. Another factor was the imposition of antidumping duties, ranging from 40.46 to 108 weighted average margin percent, on imports of low cost Russian ferrovanadium and nitrided vanadium into the United States.

Current Research and Technology

A family of oxides that contracts uniformly when heated near room temperature reportedly has been discovered. The new materials, discovered by researchers at Oregon State University, are the first that shrink in all three dimensions when heated at or above room temperature. Most materials expand when heated, though a few are known to expand in some dimensions and contract in others. Some glasses are known to contract uniformly in all directions, but only at temperatures below room temperature. The materials contain zirconium, vanadium, phosphorus, and oxygen, with a typical composition being $ZrVPO_7$. Contraction occurs because the bond angle in certain linkages, such as P-O-P and V-O-V, diminishes as the temperature increases. This behavior was seen from room temperature to 900° C. Such contracting materials could be combined with expanding materials to form a composite whose dimensions do not change on heating or cooling. This type of composite would be of interest as a structural material in optical and electronic devices, whose performance can be affected by thermal contraction and expansion.[2]

An experimental ferritic steel, under development at Mintek in the RSA, was said to have properties that are equal to or superior to the austenitic grades. The new iron-base alloy contains 18% chromium and up to 4% vanadium. According to Mintek, the alloy had superior resistance to corrosion induced pitting in chloride solutions. This feature, combined with a ductile-to-brittle temperature of less than -40° C, gave the new alloy the potential to capture part of the market for type 304 and type 316 stainless steel.[3]

Outlook

World steel production, which consumes more than 90% of total vanadium demand, was expected to continue to recover in 1995. Relatively vigorous growth in all markets in 1995 was expected to lead to an increase of about 3.5% in global apparent steel consumption, equal to an increase of more than 21 million tons of finished products. Reflecting the recovery in apparent steel consumption, production of crude steel at the world level was expected to increase by about 3.2% to 746 million tons.[4] At that level, world demand for vanadium was expected to be 61,000 tons of V_2O_5 equivalents. The U.S. steel industry forecasted strong demand for 1995. Estimates for 1995 U.S. mill shipments ranged from 90 to 95 million tons.[5] At that level, U.S. demand for vanadium was expected to be 7,770 tons V_2O_5 equivalents. Whatever the short to medium-term prospects of the steel industry, stability in the vanadium industry will depend on the possibility of further new vanadium capacity and the reopening of mothballed plants. Vanadium supply and demand should remain in balance through 1995, provided there is no new capacity and the mothballed plants remain closed.

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[1] Federal Register, v. 60, No. 2, Wed., Jan. 4, 1995, pp. 438-441.

[2] Chemical and Engineering News, Sept. 5, 1994, p. 35.

[3] MINTEK Bulletin, No. 78, Nov. 1994.

[4] Steel Times International, v. 19, No. 1, Jan. 1995, p. 4.

[5] Iron Age-New Steel, v. 11, No. 1, Jan. 1995, p. 10.

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Metal Price Support (London).

Metalworking News.

Roskill Reports (London).

TABLE 1
SALIENT VANADIUM STATISTICS 1/

(Metric tons of contained vanadium unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium 2/	W	W	W	W	W
Value thousands	W	W	W	W	W
Vanadium oxide recovered from ore 3/	W	W	W	W	W
Vanadium recovered from petroleum residues 4/	2,310	2,250	1,350	2,870	2,740 e/
Consumption	4,080	3,290	4,080	3,970	4,290
Exports:					
Ferrovanadium	271	94	213	219	374
Vanadium pentoxide (anhydride)	819	700	26	126	335
Other oxides and hydroxides of vanadium	976	1,110	1,110	895	1,050
Imports for consumption:					
Ferrovanadium	244	420	592	1,630	1,910
Vanadium pentoxide (anhydride)	83	133	206	70	294
Other oxides and hydroxides of vanadium	271	110	103	19	3
Ore, slag, ash, and residues	3,830	882	838	1,450	1,900
World: Production from ore, concentrate, slag 5/	36,900 r/	34,300 r/	31,500 r/	33,400 r/	33,900 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mill, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

3/ Produced directly from all domestic ores and ferrophosphorus slag; includes metavanadates.

4/ Includes vanadium recovered from fly ash, residues, and spent catalysts.

5/ Excludes U.S. production.

TABLE 2
U.S. VANADIUM PENTOXIDE PRODUCERS

Producer	Plant location	Capacity (metric tons pentoxide per year)
AMAX Metals Recovery Inc.	Braithwaite, LA	1,800
Energy Fuels Nuclear, Inc.	Blanding, UT	6,800
Gulf Chemical & Metallurgical Corp.	Freeport, TX	1,400
Kerr-McGee Chemical Corp.	Soda Springs, ID	2,000
U.S. Vanadium Corp.	Hot Springs, AR	6,800

TABLE 3
U.S. CONSUMPTION AND CONSUMER STOCKS OF VANADIUM MATERIALS 1/

(Kilograms of contained vanadium)

Form	1993		1994	
	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium 2/	3,600,000 r/	297,000	3,890,000	446,000
Oxide	15,100	9,200	18,700	9,970
Ammonium metavanadate	2,170	1,900	W	W
Other 3/	348,000 r/	20,700	382,000	17,500
Total	3,970,000	329,000	4,290,000	473,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes other vanadium-iron-carbon alloys as well as vanadium oxides added directly to steel.

3/ Consists principally of vanadium-aluminum alloy and small quantities of other vanadium alloys and vanadium metal.

TABLE 4
U.S. CONSUMPTION OF VANADIUM IN 1994, BY END USE 1/

(Kilograms of contained vanadium)

End use	Quantity
Steel:	
Carbon	1,680,000
Stainless and heat-resisting	26,000
Full alloy	777,000
High-strength low-alloy	979,000
Tool	424,000
Unspecified	10,500
Total	3,890,000
Cast irons	31,400
Superalloys	15,600
Alloys (excluding steels and superalloys):	
Cutting and wear-resistant materials	311
Welding and alloy hard-facing rods and materials	2,750
Magnetic alloys	W
Other alloys	323,000
Chemical and ceramic uses:	
Catalysts	W
Pigments	W
Miscellaneous and unspecified	22,800
Grand total	4,290,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

1/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to total shown.

TABLE 5
U. S. EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Aluminum-vanadium master alloy: 2/ (gross weight)				
Australia	3,560	$67,500	274	$3,570
Brazil	2,170	29,300	20,900	30,700
Canada	153,000	2,000,000	127,000	1,680,000
Egypt	1,440	20,100	--	--
France	752	12,700	172	18,500
Germany	85	13,900	8,520	107,000
Hong Kong	248	3,230	1,990	25,900
India	--	--	1,590	20,700
Indonesia	--	--	1,540	20,000
Israel	323	4,190	--	--
Italy	--	--	130	3,610
Japan	13,200	166,000	27,300	488,000
Korea, Republic of	6,180	83,700	256	29,100
Malaysia	195	2,530	2,160	28,000
Mexico	589,000	7,660,000	758,000	9,860,000
Netherlands	8,550	313,000	--	--
Norway	--	--	362	4,710
Romania	3,410	44,300	--	--
Saudi Arabia	--	--	233	3,410
Singapore	--	--	3,200	41,500
South Africa, Republic of	78,900	273,000	--	--
Spain	--	--	10,300	7,940
Taiwan	1,860	20,900	7,960	96,900
United Kingdom	2,320	46,200	41,800	233,000
Venezuela	568	7,380	11,600	151,000
Total	866,000 r/	10,800,000	1,030,000	12,900,000
Ferrovanadium:				
Canada	163,000	1,870,000	319,000	3,420,000
Colombia	--	--	375	9,600
Japan	--	--	4,100	137,000
Mexico	45,300	551,000	38,700	552,000
South Africa, Republic of	--	--	593	19,800
Sweden	10,800	359,000	2,970	99,000
Taiwan	--	--	4,260	44,000
United Kingdom	--	--	3,750	125,000
Total	219,000	2,780,000	374,000	4,410,000
Vanadium pentoxide (anhydride): 3/				
Australia	--	--	300	2,850
Belgium	5,230	49,700	207,000	1,160,000
Brazil	--	--	34,800	214,000
Chile	1,280	12,200	302	2,870
Finland	1,070	12,100	--	--
Germany	92,400	380,000	18,200	90,200
Italy	--	--	5,020	37,100
Japan	--	--	13,700	87,400
Kuwait	3,270	24,500	--	--
Mexico	820	16,800	16,900	137,000
Netherlands	--	--	15,900	87,800
Netherlands Antilles	--	--	363	3,450
Pakistan	5,090	79,700	3,970	50,800
South Africa, Republic of	16,800	136,000	60	2,700
Spain	--	--	418	3,970
Switzerland	--	--	15,900	83,400
Trinidad and Tobago	--	--	2,500	38,500
Total	126,000	710,000	335,000	2,000,000

See footnotes at end of table.

TABLE 5 -- Continued
U. S. EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Other oxides and hydroxides of vanadium:				
Austria	--	--	589	$32,600
Belgium	19,500	$81,300	--	--
Brazil	--	--	12,200	250,000
Canada	627,000	2,920,000	679,000	3,230,000
Chile	--	--	9,740	51,700
France	3,250	265,000	69,200	571,000
Germany	--	--	1,870	9,560
Hong Kong	--	--	17	2,920
Japan	36,300	143,000	14,500	71,600
Mexico	13,300	38,500	2,910	11,900
Netherlands	16,000	115,000	7,770	88,900
Nicaragua	--	--	5,340	36,100
Russia	--	--	2,600	274,000
South Africa, Republic of	64,500	288,000	156,000	630,000
Sweden	89,800	535,000	--	--
United Kingdom	--	--	4,970	36,700
Venezuela	25,200	158,000	84,400	575,000
Total	895,000	4,540,000	1,050,000	5,870,000

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes vanadium metal.

3/ May include catalysts containing vanadium pentoxide.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Aluminum-vanadium master alloy: (gross weight)				
Germany	19,100	$499,000	38,400	$948,000
Ferrovanadium:				
Austria	160,000	1,520,000	78,400	628,000
Belgium	46,100	328,000	--	--
Canada	387,000	3,560,000	639,000	5,270,000
France	8,610	81,700	--	--
Germany	179,000	1,120,000	31,000	181,000
Japan	30,600	235,000	--	--
Russia	688,000	4,380,000	1,110,000	6,480,000
Switzerland	39,500	308,000	--	--
Ukraine	40,800	304,000	9,480	53,100
United Kingdom	48,900	394,000	37,300	238,000
Total	1,630,000	12,200,000	1,910,000	12,900,000
Vanadium pentoxide (anhydride): 2/				
Canada	1,050	17,500	138	2,300
France	--	--	851	152,000
Germany	580	13,000	848	24,300
Russia	--	--	80,700	250,000
South Africa, Republic of	68,200	350,000	211,000	1,290,000
United Kingdom	--	--	, 14	47 700
Total	69,800	381,000	294,000	1,770,000
Other oxides and hydroxides of vanadium:				
Canada	32	2,930	238	4,020
China	--	--	3,230	35,700
France	8,270	140,000	--	--
Germany	647	12,500	2	1,630
Russia	740	4,470	--	--
South Africa, Republic of	2,140	8,720	--	--
United Kingdom	6,850	124,000	--	--
Total	18,700	292,000	3,470	41,300
Vanadium metal, including waste and scrap: (gross weight)				
Canada	--	--	73	9,260
Germany	11,400	287,000	41,200	1,420,000
Japan	1	1,280	--	--
Russia	--	--	880	41,200
South Africa, Republic of	618,000	5,210,000	528,000	4,400,000
United Kingdom	199	22,900	151	10,600
Total	630,000	5,520,000	570,000	5,880,000

1/ Previously published and 1994 data are rounded by the U. S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ May include catalysts containing vanadium pentoxide.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH, RESIDUES AND SLAG 1/

(Kilograms, vanadium pentoxide content)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Ash and residues:				
Barbados	18,000	$7,940	--	--
Canada	439,000	533,000	295,000	$187,000
Dominican Republic	80,000	60,000	--	--
Germany	202,000	142,000	392,000	50,100
Israel	77,300	104,000	--	--
Italy	250,000	180,000	--	--
Jamaica	7,130	17,900	--	--
Korea, Republic of	--	--	16,100	3,220
Mexico	1,010,000	461,000	1,390,000	523,000
Netherlands	12,700	8,320	6,730	9,300
Netherlands Antilles	9,180	5,420	170,000	58,900
Portugal	16,000	84,900	--	--
South Africa, Republic of	--	--	11,000	1,730
United Kingdom	56,000	42,500	--	--
Venezuela	60,300	63,200	108,000	121,000
Total	2,240,000	1,710,000	2,380,000	954,000
Slag, from the manufacture of iron and steel: 2/				
South Africa, Republic of	316,000	1,530,000	1,000,000	1,110,000
Other residues: (not advanced in value)				
Argentina	7,660	5,120	--	--
Canada	15,900	20,500	6,760	4,390
France	14,200	54,200	--	--
Total	37,800	79,800	6,760	4,390

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ As adjusted by the U.S. Bureau of Mines.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS VANADIUM CHEMICALS 1/ 2/

(Kilograms, vanadium content)

Material and country	1993		1994	
	Quantity	Value	Quantity	Value
Vanadates:				
Canada	84	$3,250	--	--
France	562	255,000	76	$159,000
Germany	36,800	286,000	7,490	71,300
Japan	--	--	4,230	13,000
Netherlands	--	--	4	19,200
South Africa, Republic of	23,400	181,000	17,900	96,700
United Kingdom	1,510	48,900	80	89,900
Total	62,400	774,000	29,700	449,000
Hydrides and nitrides:				
Canada	4,360	5,130	--	--
Sweden	--	--	3	5,090
Total	4,360	5,130	3	5,090

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Comprises vanadium ore and miscellaneous vanadium chemicals received for immediate consumption plus material withdrawn from bonded warehouses.

Source: Bureau of the Census.

TABLE 9
WORLD VANADIUM PENTOXIDE ANNUAL PRODUCTION CAPACITY, DECEMBER 31, 1994 1/ 2/

(Metric tons of contained vanadium)

Country	Rated capacity 3/
Austria	1,500
Canada	770
Chile	2,300
China	8,200
South Africa, Republic of	27,200
Russia	9,500
United States	11,000
Venezuela	2,500
Other	550
Total	63,500

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to total shown.

2/ Includes vanadium pentoxide in vanadiferous iron slags and petroleum refinery residues.

3/ Includes capacity of operating plants as well as plants on standby status.

TABLE 10
VANADIUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of contained vanadium)

Country	1990	1991	1992	1993	1994e/
Production from ores, concentrates, slag: 3/					
China (in vanadiferous slag product) e/	4,500	4,500	4,700	5,000	5,000
Hungary e/	300	200	200	200	200
Russia e/ 4/	XX	XX	11,000 r/	10,000 r/	10,000
South Africa, Republic of: 5/					
Content of pentoxide and vanadate products e/	7,100	6,500	6,300	8,400 r/	8,600
Content of vanadiferous slag product e/ 6/	10,000	8,460	7,730	6,650 r/	7,100
Total	17,100	15,000	14,000	15,100 r/	15,700 7/
U.S.S.R. e/ 3/ 8/	12,000 r/	12,000 r/	XX	XX	XX
United States (recoverable vanadium)	W	W	W	W	W
Total	33,900 r/	31,700 r/	29,900 r/	30,300 r/	30,900
Production from petroleum residues, ash, spent catalysts: 9/					
Japan e/	700	404 r/	245 r/	252 r/	300
United States	2,310	2,250	1,350	2,870	2,740 7/
Total	3,010	2,650 r/	1,590 r/	3,120 r/	3,040
Grand total	36,900 r/	34,300 r/	31,500 r/	33,400 r/	33,900

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ In addition to the countries listed, vanadium is also recovered from petroleum residues in Germany, and several other European countries, but available information is insufficient to make reliable estimates. Table includes data available through June 16, 1995.

3/ Production in this section is credited to the country that was the origin of the vanadiferous raw material.

4/ All production in the U.S.S.R. from 1990-91 came from Russia.

5/ Includes production for Bophuthatswana.

6/ Data on vanadium content of vanadium slag are estimated on the basis of a reported tonnage of vanadium-bearing slag (gross weight) multiplied by an assumed grade of 14.1% vanadium.

7/ Reported figure.

8/ Dissolved in Dec. 1991.

9/ Production in this section credited to the country where the vanadiferous product is extracted; available information is inadequate to permit crediting this output back to the country of origin of the vanadiferous raw material.

VERMICULITE

By Michael J. Potter

Vermiculite is a mica-like mineral that rapidly expands upon heating to produce a lightweight material. This expanded (exfoliated) product is used as lightweight aggregate in concrete, plaster, and premixes. Vermiculite also is used in building boards of various types such as fire-resistant plaster board, some lightweight wall boards, various refractory board products, etc.[1] In 1994, the largest end use for vermiculite continued to be in potting soils and other horticultural products, as a soil conditioner, fertilizer carrier, etc.

Production

U.S. vermiculite concentrate sold and used was 180,000 metric tons (mt), or down slightly from that of the previous year, according to the U.S. Bureau of Mines (USBM). The tonnage of exfoliated vermiculite sold and used was 130,000 mt, compared with 140,000 mt in 1993.

Domestic production data for vermiculite were developed by the USBM from two separate voluntary surveys, one for domestic mine operations and the other for exfoliation plant operations. Of the four known mine-mill operations to which a survey request was sent, data were obtained from three operations. This represented a response rate of 75%. Data for the one nonrespondent were estimated by the USBM. Of the 25 known active exfoliating plants to which a survey request was sent, data were obtained for 20. This represented a response rate of 80%. The five nonrespondents' data were estimated by the USBM using previous years' production levels.

W. R. Grace & Co. was again believed to have been the largest domestic producer of vermiculite concentrate from its operation at Enoree, SC. Other producers during the year were Virginia Vermiculite Ltd., with an operation near Woodruff, SC, and another in Louisa County, VA; and Patterson Vermiculite Co., near Enoree, SC.

Domestic sales of exfoliated vermiculite by 17 known producers shown in Table 3 came from 25 plants in 16 States. Of these plants, eight in seven States were operated by W. R. Grace. In descending order of output sold and used, the largest producing States of U.S. exfoliated vermiculite were estimated to be Ohio, South Carolina, Pennsylvania, Illinois, Arizona, Arkansas, Florida, and New Jersey.

Prices for U.S. vermiculite concentrate, converted to dollars per metric ton, were approximately $72 to $149 for raw, FOB plant, bulk material. Prices for South African concentrate were approximately $116 to $187 per metric ton for crude, bulk, FOB barge, Gulf coast material.[2]

World Review

Capacity.—The data in Table 4 are an approximation of rated annual capacity for vermiculite plants as of December 31, 1994. Rated capacity is defined as the maximum quantity of product that can be produced on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that in the judgement of the author can be brought into production within a short period of time with minimum capital expenditure. Plant capacity would ideally be based on engineering capacity provided by the companies. However, because data were not available, plant capacity data in Table 4 were estimated by considering recent peak production during the past 5 years to be equal to rated capacity.

In Australia, Helix Resources NL announced its application for a mining lease for its vermiculite deposit at Hillview, Western Australia. The company had suspended development of the deposit earlier. However, Helix was planning to evaluate the viability of supplying the Australian vermiculite market from a small production operation at Hillview.[3]

In Russia, more than 20 vermiculite deposits had been discovered. The versatility of the mineral has been recognized for some time: it does not burn or rot; is chemically inert; is a heat and sound insulating material; is a medium for growing vegetables by hydroponic methods; is an excellent absorber of heavy metal ions and radionuclides; etc. In 1978, a vermiculite concentrate plant was installed in Kovdor in the Murmansk Region. Earlier, in 1957, the Branch Scientific Research Institute of Building Materials "UralNIIstromproject" was established in Chelyabinsk. Its purpose was for the design and development of equipment and technology to produce exfoliated vermiculite and products that contain vermiculite. During subsequent years, a subbranch was established for the production of building materials. The enterprise "Techservice Vermiculite" was established and developed technology for processing lower-grade vermiculite ores without losing quality in final products. The technology can treat ores from small deposits that occur in many countries of the world. Detailed analyses had been carried out on vermiculite ores from Bulgaria, Egypt, India, Korea, Turkey, and other countries. Vermiculite exfoliation plant projects had been developed for Australia, Cyprus, and Spain. Production operations established in other countries were using raw material from Russia. In cooperation with foreign business partners, new production projects can be carried out, including raw material investigation, project design, and equipment manufacture, mounting, and startup. Marketing services can be rendered and raw material supplied. Technology was also available to produce vermiculite products, including ceramic-vermiculite products for insulation of furnace installations with operating temperatures up to 1100° C.[4]

In Zimbabwe, Shawa Vermiculite Pvt. Ltd. completed a new processing plant with a capacity of 24,000 metric tons per year. When combined with the existing operations, this gave the company a total production capacity of 39,000 metric tons per year. Some of the equipment at the new plant included a rotary drier, screening tables and winnowers. With a new, fully equipped quality control lab, the company was said to be able to manufacture products that are well within international specifications.

Shawa was said to have high-quality ore. Over the past several years the company has had the approval of a number of overseas countries, including Denmark. No asbestos had been found in Shawa's material.[5]

Outlook

The cation exchange potential of vermiculite is one of its properties that can be used as a basis for various products such as intumescent coatings and gaskets. For example, this gasketing material is used extensively as wrap-around mats to cushion catalytic converter assemblies in automotive applications.

Possible new applications for vermiculite in all of its forms include detoxification of water and soil, nuclear waste containment and removal, and industrial spill containment and cleanup. A comprehensive list of 350 patents issued in 1994 was published which apply to basic vermiculite technologies, or mention vermiculite in the description of the invention.[6]

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TABLE 1
SALIENT VERMICULITE STATISTICS 1/

(Thousand metric tons and thousand dollars)

	1990	1991	1992	1993	1994
United States:					
Sold and used by producers:					
Concentrate	209 e/	180	190	190	180
Value	$19,100 e/	W	W	W	W
Average value 2/	$91 e/	W	W	W	W
Exfoliated	142	136	140	140	130
Value	$39,400	$38,600	$45,900	$46,700	$43,600
Average value 2/	$277	$284	$328	$338	$335
Exports to Canada	18 e/	10 e/	8 e/	7 e/	7 e/
Imports for consumption	45 e/	38 e/	40 e/	30 e/	30 e/
World: Production 3/	572 r/	517 r/	463 r/	494 r/	486 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Based on rounded data.

3/ Excludes production by countries for which data were not available.

TABLE 2
EXFOLIATED VERMICULITE
SOLD AND USED IN THE UNITED STATES, BY END USE 1/

(Metric tons unless otherwise specified)

	1993	1994
Aggregates:		
Concrete	18,600	16,300
Plaster	800	600
Premixes 2/	8,800	4,500
Total	28,200	21,400
Insulation:		
Loose-fill	W	W
Block	W	W
Other 3/	1,400	1,400
Total	32,800	30,500
Agricultural:		
Horticultural	25,100	26,300
Soil conditioning	13,100	15,300
Fertilizer carrier e/	32,100	30,500
Total e/	70,300	72,000
Other 4/	6,400	5,400
Grand total	140,000	130,000

e/ Estimated. W Withheld to avoid disclosing company propietary data; included in "Total."

1/ Data rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes acoustic, fireproofing, and texturizing uses.

3/ Includes high-temperature and packing insulation and sealants.

4/ Includes various industrial, etc., uses not specified.

TABLE 3
ACTIVE VERMICULITE EXFOLIATING PLANTS IN THE UNITED STATES IN 1994

Company	County	State
A-Tops Corp.	Beaver	Pennsylvania.
Brouk Co.	St. Louis	Missouri.
W. R. Grace & Co., Construction Products Div.	Jefferson	Alabama.
Do.	Maricopa	Arizona.
Do.	Orange	Do.
Do.	Broward	Florida.
Do.	Du Page	Illinois.
Do.	Campbell	Kentucky.
Do.	Multnomah	Oregon.
Do.	Laurens	South Carolina.
Koos Inc.	Kenosha	Wisconsin.
Palmetto Vermiculite Co., Inc.	Laurens	South Carolina.
Patterson Vermiculite Co.	do.	Do.
P.V.P. Industries	Trumbull	Ohio.
The Schundler Co.	Middlesex	New Jersey.
O.M. Scott & Sons.	Union	Ohio.
Southwest Vermiculite Co., Inc.	Bernalillo	New Mexico.
Strong-Lite Products Corp.	Jefferson	Arkansas.
Strong Products Corporation	Lesalle	Illinois.
Thermic Refractories, Inc.	Macoupin	Do.
Thermo-O-Rock, Inc.	Maricopa	Arizona.
Do.	Washington	Pennsylvania.
Verlite Co.	Hillsborough	Florida.
Vermiculite Industrial Corp.	Allegheny	Pennsylvania.
Vermiculite Products, Inc.	Harris	Texas.

TABLE 4
WORLD VERMICULITE ANNUAL PRODUCTION CAPACITY
DECEMBER 31, 1994

(Thousand metric tons)

Country	Rated capacity 1/ 2/
North America:	
Mexico	(3/)
United States	190
Total	190
South America: e/	
Argentina	4
Brazil	23
Total	27
Europe:	
Russia e/	95
Africa:	
Egypt	1
Kenya	3
South Africa, Republic of	223
Total	227
Asia:	
India	2
Japan e/	15
Total	17
World total 4/	560

e/ Estimated.

1/ Includes capacity at operating plants as well as at plants on standby basis.

2/ Excludes countries for which data were not available.

3/ Less than 1/2 unit.

4/ Rounded.

TABLE 5
VERMICULITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina	3,330	3,950	4,450	4,500 e/	3,000
Brazil	23,300	11,000 r/	14,000 r/	14,000 r/	14,000
Egypt	28	519	500 e/	500 e/	500
India	1,770	1,770	1,610 r/	1,410 r/	1,500
Japan e/	15,000	15,000	15,000	15,000	15,000
Kenya e/	2,660 4/	2,600	2,600	2,600	2,600
Mexico	132	117	125	134	300 4/
Russia e/ 5/	XX	XX	60,000	50,000	40,000
South Africa, Republic of	220,000	215,000	170,000	211,000 r/	223,000 4/
U.S.S.R. e/ 5/ 6/	95,000	85,000	XX	XX	XX
United States (sold and used by producers)	209,000	180,000	190,000	190,000	177,000 4/
Zimbabwe	1,000 e/	2,320	4,300	5,030	8,180 4/
Total	572,000 r/	517,000 r/	463,000 r/	494,000 r/	486,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previosly published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Excludes production by countries for which data are not available and for which general information is inadequate for formulation of reliable estimates. Table includes data available through July 26, 1995.

3/ In addition to the countries listed, Tanzania may produce vermiculite, but available information is inadequate to make reliable estimates of output levels.

4/ Reported figure.

5/ All production in the former U.S.S.R. for 1990-91 came from Russia.

6/ Dissolved in Dec. 1991.

WOLLASTONITE

By Robert L. Virta

Wollastonite is a calcium metasilicate ($CaSiO_3$). It has a theoretical composition of 48.3% CaO and 51.7% SiO_2 but it may contain trace to minor amounts of aluminum, iron, magnesium, manganese, potassium, and sodium. Wollastonite occurs as massive or short prismatic crystals that cleave into massive to acicular fragments. It usually is white but also may be gray, brown, or red, depending on its composition.[1]

Wollastonite forms when impure limestones are metamorphosed (subjected to heat and pressure) or silica-bearing fluids are introduced into calcareous sediments during the metamorphic process. In both cases, calcite reacts with silica to produce wollastonite and carbon dioxide.[1 2]

Deposits of wollastonite have been found in Arizona, California, Idaho, Nevada, New Mexico, New York, and Utah. These deposits are typical skarns containing wollastonite as the major component and calcite, diopside, garnet, idocrase, and/or quartz as minor components.[1 2]

Production

Wollastonite has been mined commercially in California and New York. Wollastonite was mined in California between 1930 and 1970 from deposits in Inyo, Kern, and Riverside Counties. These operations were limited in size, producing only a few thousand tons of wollastonite per year for ceramics, decorative stone, paint, and mineral wool production.[2 3]

Mining in New York began in the 1940's and has continued to the present day from deposits in Essex and Lewis Counties.[2 3] Two companies currently are mining wollastonite. NYCO, a division of NYCO Minerals Inc., operated a mine in Essex County and R. T. Vanderbilt Co. Inc. operated a mine in Lewis County. The NYCO deposit contains about 60% wollastonite, 30% garnet, and 10% diopside. The ore is processed at their Willsboro plant where the diopside and garnet are removed using magnetic separators. Besides its ground products, NYCO also produces surface-treated wollastonite. The R. T. Vanderbilt deposit in Lewis County is relatively pure with only minor amounts of calcite and diopside. The company processes its ore at its Balmat plant.[2 3] Domestic wollastonite sales increased 16% from that of 1993.

Consumption

Wollastonite is used in abrasive products, adhesives, brake linings, ceramics, friction products (brakes and clutches), glass insulation, glazes, metallurgical applications, paint, plasters, refractories, and wallboard. The major uses are in ceramics, plastics, and paint. In ceramics, wollastonite acts as a flux, reduces lamination during pressing of tiles, protects against thermal shock, decreases shrinkage during firing, increases strength, reduces moisture expansion of the fired body, permits fast firing, and reduces crazing. As a filler in paint, wollastonite reinforces the paint film, acts as a pH buffer, improves its resistance to weathering, reduces pigment consumption, and acts as a flatting and suspending agent. In plastics, wollastonite improves the tensile and flexural strength, reduces the consumption of expensive resins, increases the electrical resistance, and improves thermal and dimensional stability at elevated temperatures. Wollastonite used in paints and plastics may be surface treated to improve the adhesion between the wollastonite and the polymers, thereby improving the characteristics of the finished product. In Europe, another major use is in metallurgical applications. Wollastonite is used as a flux for welding and for controlling casting speed during continuous casting of steel.[2 3 4]

Wollastonite also is used as an asbestos substitute. It is acicular when ground so it is a good reinforcer in paints and plastics. Wollastonite is resistant to chemical attack, relatively inert, and stable at high temperatures, making it a good replacement for asbestos in plastics, paints, and insulating board. Wollastonite has been used in insulating boards and panels, floor tiles, plastics, roofing, and friction products.[3 5]

Prices

Prices from Industrial Minerals, December 1994, for wollastonite, ex-works, acicular, were $198 per metric ton for minus 200 mesh; $247 for minus 325 mesh; and $273 for minus 400 mesh. The price, ex-works, for acicular, high-aspect-ratio material was $308 per ton, and for ground (10 micron) material, $620 per ton. Prices per ton for wollastonite, f.o.b. plant, bulk, were $170 for 200 mesh and $214 for 325 mesh. Quoted prices should be used only as a guideline because actual prices depend on the terms of the contract between seller and buyer.

World Review

Worldwide production of wollastonite was estimated to be 365,000 tons in 1993.[6] Production for 1994 should be slightly higher, possibly approaching 400,000 tons, based on industry reports. Estimates for wollastonite production in individual countries in 1993 were 150,000 tons for China, 27,000 tons for Finland, 80,000 tons for India, and 36,000 tons for Mexico. Industry experts estimated U.S. production to exceed 100,000 tons. Production in Chile, North Korea, Pakistan, the Republic of South Africa, and Turkey accounted for the remainder.

NYCO Minerals Inc. continued work on its project in Sonora, Mexico, and Orleans Resources Inc. continued its testing of ore from its St. Onge, Quebec deposit. Ram Petroleum Ltd. announced plans to produce wollastonite from its Olden Township deposit in Ontario and Sociedad Minera San Albin SA continued with its plans to mine wollastonite from a deposit near Madrid, Spain. Gwalia Consolidated Ltd. began examining wollastonite deposits in Queensland, Australia. Partners were being sought for testing and/or developing wollastonite deposits in Brazil, New Zealand,

and Spain.

Lishu Wollastonite Mining Industry Co. began mining wollastonite at the Shijianfang location in northeast China. The site contains 2 million tons of wollastonite reserves. Mine production capacity is 20,000 tons per year. The ore was processed at Lishu's Dadingshan mill. Markets for the wollastonite include building materials and rubber.[7]

Outlook

Industry experts are optimistic about the future of wollastonite, predicting that the worldwide production will approach 700,000 tons by the year 2000. Major markets for wollastonite will continue to be in ceramics, plastics, and paints. The use of wollastonite as an asbestos substitute should remain steady.

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ZEOLITES

By Robert L. Virta

Natural Zeolites

Zeolites are hydrated aluminosilicates of the alkaline and alkaline-earth metals. Approximately 40 natural zeolites have been identified over the past 200 years, the most common of which are analcime, chabazite, clinoptilolite, erionite, ferrierite, heulandite, laumontite, mordenite, and phillipsite. Zeolites are commercially valuable because of their unique ion-exchange, molecular sieving, and catalytic properties.

Commercial zeolite deposits in the United States are associated with the alteration of volcanic tuffs in saline, alkaline lake deposits and open hydrologic systems. The deposits are located in Arizona, California, Idaho, Nevada, New Mexico, Oregon, Texas, Utah, and Wyoming. The major components of these deposits are chabazite, clinoptilolite, mordenite, and phillipsite. Erionite, orthoclase and plagioclase feldspar, montmorillonite, opal, quartz, and volcanic glass may be present in some deposits. The composition of these deposits was determined primarily by the temperature and pressure of formation and the chemistry of the altering fluids. If the alteration process has gone to completion, the zeolite content of portions of some deposits may approach 100%.

Production.—Conventional mining techniques were used in the mining of natural zeolites. The overburden was removed to allow access to the ore and the ore was stripped for processing using front-end loaders or tractors equipped with ripper blades. Fractured ore was dried and then crushed using either jaw crushers or roller mills. The crushed ore was packaged directly for shipping or was screened to remove fine material when a granular product was required.

Eight companies mined or sold natural zeolites in the United States in 1994. Clinoptilolite was mined and/or processed in California, Nevada, New Mexico, Oregon, and Texas; chabazite was mined in Arizona. Total domestic production was 52,800 metric tons.

Consumption.—Sales were 35,200 tons in 1994, a slight decrease from that of 1993. Natural zeolites were used for pet litter, animal feed supplement, fertilizer carrier, oil absorbent, odor control, aquaculture, horticultural applications, desiccants, gas absorbents, catalysts, and water purification, in decreasing order of consumption. As in previous years, over 50% of the natural zeolite was consumed as pet litter. Consumption patterns for most applications did not change. The only exception was with pet litter applications, where the reported consumption of zeolites declined. The properties that made natural zeolites commercially valuable included ammonium adsorption (aquaculture, aquarium filters, odor control applications, pet litter, and water purification), moisture adsorption (desiccants, odor control, and pet litter), and ion-exchange capabilities (wastewater cleanup and water purification).

Successful marketing of natural zeolites is dependent on selecting the proper zeolite for a specific application. A review paper discussed the properties of zeolites and recommended that information such as form, color, crystal structure, pore diameters, void volume, packing, etc. be determined for each zeolite product. This information will help the customer choose the proper zeolite for a specific application.[1]

World Review.—**Australia.**—Zeolite Australia Ltd. worked with Global Soil Systems and Envirosciences Pty. Ltd. to market its natural zeolites. Their primary markets were animal feed supplements and acid mine drainage clean-up.[2]

Canada.—Princeton Zeolite Products Inc. and Princeton Industrial Mineral Joint Venture signed a letter of intent to sell their zeolite properties in British Columbia to I.M.P.A.C.T. Minerals Inc. I.M.P.A.C.T. Minerals will begin a bulk sampling program of the deposit and do market development.[3]

Cuba.—The International Marketing Firm for Industrial Minerals S.A. reported zeolite production of 600,000 tons per year in Cuba. Exports, primarily to Brazil, Colombia, Ecuador, France, Italy, Mexico, and Spain, were reported to be greater than in the previous 4 years combined.[4]

Current Research and Technology.—The U.S. Bureau of Mines continued its work on using natural zeolites for treating acid mine drainage. As part of the study, the recycle characteristics of zeolites were determined. No decrease in the cation exchange capacities of the zeolites tested were detected after 40 loading and stripping cycles. Other work focussed on the removal of arsenic and other heavy metals from wastewaters. One study demonstrated that a calcium clinoptilolite removed low levels of cadmium, manganese, and zinc from mine wastewater, providing additional options for sludge disposal and lower costs for water treatment. Another study involved the pretreatment of natural zeolites with ferric sulfate solutions. The iron precipitates on the zeolites served as the collector for arsenic.

Synthetic Zeolites

Producers of synthetic zeolites announced plans to construct new plants and expand existing plants and introduced several new zeolites. Akzo Nobel began construction of a zeolite plant in Pasadena, TX and W. R. Grace announced plans to build a zeolite plant in Louisiana that will supply catalysts to its fluidized cracking catalyst plant. This activity is in response to growing demand for refinery catalysts in Asia.[5] United Catalysts Inc. introduced a new zeolite catalyst for use in manufacturing ethylbenzene from benzene and ethylene feedstock. The zeolite was developed jointly with Fina Technology. ABB Lummus Crest Inc. and Sinopec Technology Co. began work on commercializing its process for manufacturing ethylbenzene from benzene and dilute ethylene feedstock. The process uses a pentasil-type zeolite catalyst. The zeolite is not affected by impurities, such as H_2S, H_2O, CO, and CO_2, thereby reducing the need for feedstock pretreatment.[6] Engelhard Corp. introduced a zeolite catalyst for fluid catalytic cracking applications. The zeolite is more tolerant to nickel and vanadium and allows better control of the residual feedstock processing than other zeolite catalysts.[7] Crosfield introduced a new zeolite, A24, which was developed specifically for detergent use. The zeolite consists of smaller crystallites and has better calcium and magnesium exchange properties than other detergent-grade zeolites.[8]

Two companies announced plans to expand facilities that use synthetic zeolites. Georgia Gulf will upgrade its Pasadena, CA, cumene facility to use zeolite-based catalyst technology.[9] Lyondell Petrochemical Co. announced plans to add 2,000 to 3,000 barrels per day capacity to its zeolite-based methyl tert-butyl ether process line.[10]

Current Research and Technology.— Mobil Research and Development Corp. developed a new zeolite structure. The structure is composed of cages with dimensions of 0.71 by 0.71 by 1.82 nanometers and 10-ring apertures. Hexamethyleneimine was used as the template during the synthesis process. The zeolite may be synthesized as an aluminosilicate or a borosilicate.[11]

In other research, scientists at Perdue University synthesized oriented zeolite crystals. The crystals were grown on a gold coated silicon substrate which had been modified with an organophosphate. Oriented growth was largely attributed to the organophosphate coating. Possible uses for oriented zeolite crystals include catalytic membranes or chemical sensors for environmental monitoring.[12]

Surface modification improved the sorption characteristics of clinoptilolite for oxyanions. Clinoptilolite was treated with hexadecyltrimethylammonium (HDTMA). The surface-modified zeolite removed chromate, selenate, and sulfate from solution while the untreated zeolite did not remove these species. Anion retention was attributed to the formation of HDTMA-anion precipitates on the zeolite surface.[13]

The National Institute of Standards and Technology awarded a $2 million grant for a project to synthesize catalysts, including zeolites, on a microcrystalline scale. The objective is to synthesize crystals of uniform size and composition. These catalysts could exhibit unique properties that could improve reactivity and selectivity.[14]

Outlook

Mining and sales of natural zeolites increased from 12,000 tons in 1988 to 35,000 tons in 1994 with the peak year being 1993. Most of the sales increase resulted from the increased use of zeolites in animal feed and pet litter applications. Increases of the magnitude experienced between 1988 and 1993 are not anticipated to continue into the future. Domestic consumption for the next few years should be between 35,000 to 45,000 tons per year.

With regards to synthetic zeolites, the market with the largest growth potential are detergent applications, particularly in Asian markets. Another area for growth will be in environmental applications such as emission controls.

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TABLE 1
DOMESTIC ZEOLITES PRODUCERS, 1994

State and company	Type of zeolite
Arizona:	
GSA Resources Inc.	Chabazite
UOP Inc.	Do.
California:	
Steelhead Specialty Minerals	Clinoptilolite.
Nevada:	
American Resource Corp.	Do.
New Mexico:	
St. Cloud Mining Co.	Do.
Oregon:	
Teague Mineral Products Co.	Do.
Texas:	
Zeotech Corp.	Do.

ZINC

By Stephen M. Jasinski

Zinc was produced at 24 mines in the United States in 1994. Production increased 17% from 1993. For the fourth consecutive year, Alaska was the leading zinc-producing State, followed by Tennessee, New York, Missouri, Montana, and Colorado. U.S. mine production greatly exceeded smelter capacity, which resulted in a net export of 362,000 metric tons of zinc in concentrate. The value of zinc mine production, based on the average annual U.S. price, was $619 million.

Three smelters produced primary zinc metal in 1994 from domestic and imported ore. Seven secondary smelters produced zinc metal using about 70% new scrap and 30% old scrap. A detailed discussion of the secondary zinc industry is contained in the annual Mineral Industry Survey "Recycling — Nonferrous Metals." Total zinc metal production was 356,000 tons; a 7% decrease from 1993, caused by the indefinite closure of one primary zinc smelter in September 1993.

Domestic apparent consumption of zinc in all forms increased 5%; imports of zinc metal grew by 10% to meet the demand. Apparent consumption of slab zinc grew 5% from 1993. The increase was greatest in the galvanizing and diecasting industries owing to strong growth by the U.S. automobile industry. Zinc use in brass and bronze products increased slightly. The use of zinc in the form of compounds, dust, and powder increased 14% over that of 1993.

U.S. producer prices, which are based on the London Metal Exchange (LME) price plus a premium, rebounded slightly at the end of the year after dropping below $0.45 per pound in April. The average price for the year was $0.4926 per pound, $0.0311 higher than in 1993.

World mine production decreased 2%. Australia, Canada, China, Peru, and the United States were the top producers, in order of output, accounting for 60% of the world total. Production cuts initiated in several countries in late 1993 reduced output and greatly reduced the world surplus of zinc concentrates. World metal production, including secondary production, dropped slightly. China, Japan, Canada, Germany, and the United States were the top producers, in order of output, representing 42% of the world total. World zinc consumption increased 4%, as demand remained strong in North America and Asia (except for Japan) and improved in Europe. Zinc exports from China, Kazakhstan, North Korea, and Russia remained high, according to the International Lead And Zinc Study Group (ILZSG); the exports helped LME stocks of refined zinc to reach a record high of 1,230,000 tons at the end of August. Stocks then gradually decreased to end the year at 1,190,000 tons. However, this was a 31% increase over 1993 yearend stocks. Total world stocks were 1,800,000 tons at yearend, which represented 15 weeks of consumption, compared with 1,620,000, or 14 weeks of consumption, in 1993.

Conventional identified world zinc resources were about 1.8 billion tons. The world reserve base was estimated at 330 million tons and reserves at 140 million tons. Canada had the largest reserves, 15% of the world total; however, Australia had the largest reserve base, 20%. The U.S. share was 11% and 15% respectively.

Legislation and Government Programs

A stockpile of zinc for national defense purposes has been maintained for more than 50 years. In 1992, the President signed Public Law 102-484, which authorized the disposal of the entire inventory of zinc from the National Defense Stockpile (NDS). The Defense Logistics Agency, which maintains the NDS, was authorized to sell 45,000 tons in fiscal year (FY) 1994 (October 1, 1993 to September 30, 1994), but sold only 29,000 tons from January to September. The FY 1995 authorization was for 45,000 tons, but sales were suspended at the beginning of FY 1995 (October 1, 1994) by Congress, in response to industry complaints that NDS sales were adversely affecting the market. The FY 1995 authorization also included a provision to prevent sales if the price falls more than 5% from the date of enactment. Sales were scheduled to resume in April 1995, pending Congressional approval, with 22,680 tons authorized for sale for the remainder of the FY 1995. The inventory on December 31, 1994, was 296,000 tons.

Production

Domestic mine production data were developed by the U.S. Bureau of Mines (USBM) from a voluntary survey on Lode-Mine Production of Gold, Silver, Copper, Lead, and Zinc. All of the major zinc producing mines responded to this survey.

Mine Production.—U.S. zinc mine output increased 17% in 1994, because of increased production at the Red Dog Mine in Alaska and Asarco's mines in Missouri and Tennessee. The 15 leading mines accounted for 95% of production, with five leading mines accounting for 74%. For the fourth consecutive year, Alaska was the leading zinc-producing State, followed by Tennessee, New York, Missouri, and Colorado. The leading domestic producers were Asarco Incorporated Cominco Alaska Inc., Savage Zinc Inc., and Zinc Corp. of America (ZCA).

Savage Resources of Australia purchased the U.S. zinc operations of Union Miniére of Belgium in February for $200 million. Union Miniére had owned five zinc mines and the Clarksville, TN, smelter. Savage did not make any major changes in the facilities.

In Tennessee, zinc was produced at eight underground mines, four owned by Asarco and four owned by Savage Zinc Inc. Asarco's production was 67,700 tons of zinc in concentrate, an increase of 17,700 tons from last year, according to the company's annual report. Reported ore reserves at yearend were 4.5 million tons averaging 3.27% zinc.

The Red Dog Mine in Northwestern Alaska accounted for all zinc production in the State. Red Dog, which began operations in late 1989, is owned by NANA Regional Corp. Inc. and leased to Cominco Alaska Inc., a subsidiary of Cominco, Ltd., which owns and operates the mining and processing facilities. NANA is paid a royalty that is scheduled to increase after the capital investment plus interest is recovered by Cominco.

At Red Dog, an expansion of the grinding circuit was completed in late 1994. Two ball mills, a tower mill, and a powerplant were installed, resulting an increased production of zinc concentrates, exceeding original design capacity. According to Cominco's annual report, zinc recovery was 75%, compared with 74% in 1993, and total ore milled was 2,120,000 tons, 422,000 tons more than in 1993. The average ore grade was 18.8% zinc, up slightly from last year. The production of zinc in concentrate was 298,000 tons in 1994, 62,500 tons more than in 1993. According to the company, ore reserves at yearend were 54.3 million tons averaging 18.3% zinc, 5.5% lead, and 93 grams per ton silver. An additional 14.1 million tons of lower grade ore, averaging 10% zinc and 2.7% lead was classified as inferred reserves.

The Greens Creek polymetallic mine on Admiralty Island near Juneau, AK, remained closed in 1994. The mine is a joint venture between RTZ Ltd., through its Kennecott subsidiary (70.3%), Greens Creek Mining Co. and Hecla Mining Co. (20.7%). Development and maintenance continued during the year. Exploration drilling defined a high grade ore body first identified in 1991. According to Hecla, the new ore body is richer than the previously mined section of the mine; proven and probable reserves are 2.35 million tons, grading 13.1% zinc and 4.7% lead. In 1995, the companies were expected to announce plans to reopen the mine in the near future.

In Missouri, zinc was produced as a coproduct of lead at eight underground lead mines along the Viburnum Trend by three companies, Asarco, The Doe Run Co., and Cominco American Inc., a subsidiary of Cominco Ltd. According to Asarco's annual report, production of zinc in concentrate at the West Fork and Sweetwater Mines was 18,800 tons, an increase of 2,900 tons. Ore reserves at yearend, according to the company, were 16.2 million tons, averaging 0.73% zinc. The Magmont Mine, a joint venture of Cominco American and Dresser Industries, closed permanently in May due to depletion of the ore reserve. According to Cominco's annual report, the Magmont mill processed 287,000 tons of ore grading 1.5% zinc, yielding 3,200 tons of zinc in 5,400 tons of concentrate.

In Colorado, zinc was produced only as a coproduct of gold-silver operations at the Leadville Unit, managed by Asarco, but owned jointly with the Resurrection Mining Co. As reported in Asarco's annual report, production of zinc in concentrate was 14,000 tons, and, at yearend, ore reserves were 900,000 tons, averaging 8.44% zinc.

In Montana, the Montana Tunnels Mining Co., a subsidiary of Pegasus Gold Inc., milled 4.7 million tons of ore in 1994, yielding 18,000 tons of zinc and 8,500 tons of lead in concentrates according to the company's 10-K report. Zinc recovery was 88%, with the mill feed averaging 0.56% zinc. At yearend, according to the company, proven and probable reserves were 26.6 million tons, grading 0.60% zinc and 0.21% lead.

In Idaho, zinc was produced by Hecla Mining Co., at its Lucky Friday Mine. According to the company's 10-K report, total ore milled was 113,000 tons, yielding 2,200 tons of zinc and 12,000 tons of lead in concentrate. Production was down in 1994 because of an ore conveyance accident on August 30, 1994, which resulted in a suspension of operations for 3 months. According to the company, ore reserves were 408,000 tons averaging 2.9% zinc and 13.9% lead.

Smelter and Refinery Production.—Production of refined zinc was 356,000 tons, down from 382,000 in 1993. Primary slab zinc was produced at three smelter/refineries in 1994; Big River Zinc at Sauget, IL, Savage Zinc Inc. at Clarksville, TN, and ZCA at Monaca, PA. The ZCA smelter in Bartlesville, OK, had been closed indefinitely in late 1993. Secondary slab zinc was produced at seven plants from waste and scrap materials. The largest secondary producer was ZCA at its electrothermic smelter in Monaca, PA. A substantial part of the plant's feed material was crude zinc calcine recovered from steel mill electric arc furnace dust by its parent company, Horsehead Resource Development Co., Palmerton, PA. Other major producers of zinc metal at secondary plants were Huron Valley Steel Corp., Interamerican Zinc Co., and Gulf Metals Corp.

Zinc Oxide.—One company, Eagle Zinc Co., produced only American-process zinc oxide and four companies produced only French-process zinc oxide in 1994. Nearly 60% of U.S. production is from secondary materials. U.S. Zinc Corp., parent company of Midwest Zinc, purchased Asarco's Hillsboro, IL, zinc oxide plant in February. Midwest Zinc also operates plants in Chicago, IL, and Millington, TN. Other producers were North American Oxide, Inc. (NAO), Clarksville, TN, and ZCA, Monaca, PA. NAO began expansion of its 20,000-ton-per-year plant late in the year, with completion set for early 1995. Production was expected to be increased gradually, but the new capacity was not disclosed. NAO also purchased Purity Zinc Metals Co., Ltd., Stoney Creek, Ontario, Canada, the largest producer of high purity zinc dust in North America and the largest independent alloy producer in Canada.

U.S. production was 131,000 tons, a 4% increase over that of 1993. Some impure zinc oxide produced at secondary plants was sold directly for agricultural purposes.

Consumption

Domestic data for zinc were developed by the USBM from five separate, voluntary surveys of U.S. operations. Typical of these was the "Slab Zinc" consumption survey sent out monthly or annually, depending on consumption quantities; small consumers are canvassed annually. Consumption for nonrespondents was estimated using prior-year consumption adjusted for industry trends.

Reported consumption of zinc metal, however, accounted for only 72% of apparent metal consumption, a reflection of a low current response rate for voluntary surveys.

Zinc is found in a great many manufactured products, but its role is not obvious to the public because it tends to lose its identity in the products. Zinc-containing products were used extensively in 1994 for construction, transportation, electrical, machinery, and chemical purposes. Zinc-coated steel sheet, structural shapes, fencing, storage tanks, fasteners, nails, and wire rope were widely used in all types of construction, including transmission and radar towers, industrial plants, culverts, roads, bridges, and airfields. Zinc sacrificial anodes were used to protect ship hulls, offshore oil drilling rigs, and submerged and buried steelwork, tanks, and pipes. Brass was used as shell casings in ammunition, and in tubes, valves, motors, pipes, refrigeration equipment, heat exchangeres, communication units, and electronic devices. Zinc die-cast parts, such as handles, grilles, bezels, brackets, locks, hinges, gauges, pumps, mounts, and housings were used extensively in vehicles, heavy machinery, business machinery, appliances, household hardware, and scientific and electronic equipment. Zinc dust was used in primers and paints; in alkaline dry cell batteries; in the sherardizing process to protectively coat nuts, bolts, and small parts; for the precipitation of noble metals from solution; and in the zinc industry for the removal of impurities, such as copper, cadmium, and lead, before electrolysis. The metal casings of zinc-carbon dry cell batteries were made of rolled zinc. In 1994, 33,200 tons of Special High Grade (SHG) zinc was used by the U.S. Mint to produce 13.6 billion pennies.

The use of galvanized steel framing for residential construction continues to grow. It was used in about 5% of new homes built in the United States in 1994. The goal of the American Iron and Steel Institute is for galvanized steel frame construction to have a 25% share of new homes by 1999.

Zinc compounds were used in corrosion-inhibiting paint primers, chemical catalysts, welding and soldering fluxes, fungicides and pharmaceuticals, paints, rubber, phosphors for cathode ray tubes, ceramics, and additives for lubricating oils and greases. Zinc ferrites were used in electrical devices such as transformers, coils, amplifiers, and motors.

Domestic apparent consumption of slab zinc rose 50,000 tons to 1.19 million tons in 1994. Hot dip galvanizing and electrogalvanizing, mainly for sheet and strip, continued to be the principal use of zinc metal, consuming an estimated 53%, followed by zinc-base die-cast alloys, 20%; brass alloys, 13%; and other uses 14%. SHG accounted for about 57% of the reported consumption, followed by Prime Western, 22%; High-Grade, 13%; and other grades, 8%. Overall, zinc metal accounted for over 83% of the total zinc in final products and zinc chemicals.

Consumption of zinc in the production of copper-base alloy for brass mills, ingotmakers, and foundries increased 35,200 tons from 1993 to 348,000 tons, according to the Copper Development Association Inc. (CDA). Consumption was evenly split between refined metal and zinc contained in brass and bronze scrap metal. According to the CDA, brass mills accounted for 89% of the total zinc consumed as metal and scrap in producing copper-base alloys.

Apparent consumption of zinc oxide was about 174,000 tons. Domestic production was 131,000 tons, whereas net imports were 33,000 tons. USBM information on zinc oxide consumption reflects only shipments as reported by the domestic producers; because reporting is incomplete, the data listed in table 10 account for only about 80% of the market. Of the reported amounts, the rubber and chemical industries continued to be the principal consumers.

Stocks

Industry stocks decreased slightly from 1993. Stock numbers in table 1 represent consumer, producer, and merchant stocks. The 1992 and 1993 zinc annual reports listed only consumer stocks.

Prices

Since 1991, U.S. zinc producers have used the LME as their price basis. For domestic metal, sellers generally charged either a premium of \$0.02-to-\$0.05 per pound over the LME spot price or an average of LME prices adjusted to account for delivery and/or importing costs. The price reported in table 1 was published by *Platt's Metals Week*, which based its price on the daily LME spot price for SHG plus a premium that reflected market conditions.

The domestic price was in the range of \$0.44 to \$0.48 per pound through August, when the price began to increase in response to declining LME stocks and to speculation. The December average was \$0.5726 per pound and the 1994 average price was \$0.4926 per pound.

Foreign Trade

The value of U.S. exports of basic zinc materials, including waste and scrap, was about \$224 million, a \$27 million increase over that of 1993, owing to more exports of slab zinc and higher zinc prices. Exports of zinc concentrates increased 25% in quantity and 34% in value, owing to increased output from the Red Dog Mine.

Imports of slab zinc increased 69,000 tons to meet growing domestic demand in 1994. Slab zinc accounted for about 88% of the total value of imports of basic zinc materials (excluding alloys). Canada was the largest supplier of slab zinc, accounting for 63% of imports for consumption of slab zinc. Mexico, Peru, and Spain were other significant suppliers.

World Review

World stocks of slab zinc increased 11%, owing to a 31% increase in LME stocks, to end the year at 1,800,000 tons. Continued high exports from Eastern Europe and China combined with increased Western smelter production, pushed LME stocks to over 1,240,000 tons in August. LME stocks gradually decreased from September to the end of the year. World mine production decreased, although production increased in Peru and the United States. Stockpiles of zinc concentrates were reduced significantly as a result of the lower production levels. In Australia, CRA Ltd., began bulk sampling at its Century project in Queensland. A bulk sample of concentrate was sent to several smelters in Europe for evaluation. CRA will decide in 1995 whether to proceed with full development of the mine, which they would have operating at full production in 1998. CRA said it had identified reserves of 118 million tons grading 10.2% zinc, 1.5% lead, and 36 grams per ton silver. Annual production at full capacity for the project would be 5 million tons of ore containing 500,000 tons of zinc in concentrate.

Construction began on the McArthur River Joint Venture polymetallic mine project in the Northern Territory of Australia. First production is expected in 1995. The mine has proven and probable reserves of 26 million tons grading 14% zinc, 6.3% lead, and 63 grams per ton silver. Projected annual metal output is 160,000 tons of zinc and 45,000 tons of lead in concentrates.

In Ireland, Arcon International Plc. received planning approval for its Galmoy zinc/lead mine in County Kilkenny and began construction late in the year. Arcon expects to begin production by June 1996. Projected annual production capacity is 66,000 tons of zinc in concentrate. Proven and probable reserves, as reported by Arcon, are 6.18 million tons grading 11.10% zinc and 1.12%

lead. In County Tipperary, Ivernia West Plc. won an Irish High Court decision allowing it to acquire the 52.5% interest of Chevron Minerals Ltd. in the Lisheen zinc/lead deposit. Ivernia began development of the mine and expects to begin production in early 1997, at an annual rate of 180,000 tons of zinc in concentrate. The company reports reserves at 22.3 million tons grading 11.9% zinc, 2.0% lead, and 27 grams per ton silver.

In Tunisia, the Bougrine lead/zinc mine commenced operations, producing 26,500 tons of zinc in concentrate, which was shipped to smelters in Europe. Annual production capacity was listed at 38,000 tons of zinc in concentrates. Inferred reserves are 5.3 million tons, grading 11.7% zinc and 2.6% lead.

World metal production dropped, primarily owing to reduced output in Europe and Japan caused by high zinc inventories, low prices, and shortages of concentrates. Metaleurop S.A. closed its Noyelles-Godault zinc smelter in France after an explosion destroyed a zinc refining column. The entire facility was closed as a precaution. Metaleurop exported output from its Imperial Smelting Furnace to Belgium and Germany for final refining. The plant was expected to reopen in 1995.

In March, Cominco, Ltd. announced it would proceed with the construction of a Kivcet lead smelter to replace the inoperative QSL smelter, and expand its zinc refining circuit at Trail, B.C. The annual zinc production capacity would increase from 290,000 tons to 320,000 tons over a 3-year period. To help finance the C$17 million project, Cominco sold the rights to expand power production at two company-owned hydroelectric dams to the Province of British Columbia.

Current Research and Technology

The International Tin Research Institute has developed a 75% tin-25% zinc alloy that can be used as an environmentally friendly substitute for cadmium anticorrosion coatings on steel. The noncyanide based electrolyte, *Stanzec*, from which the coating is deposited, has been patented for rack or barrel plating and licensed to Asotec, a major U.S. plating company. Initially it will be used on automotive and aerospace parts.[1]

Outlook

Domestic mine production is expected to increase 35,000 tons in 1995 and level off in 1996, owing to improvements at several mines that will completed by 1996. Metal production is expected to increase slightly over the next 2 years, mainly from secondary production. The primary smelters have been operating near full capacity and there are no expansions likely, which will keep the United States the largest importer of zinc metal and a net exporter of zinc concentrates. Demand for zinc metal is expected to rise 2% to 3% in each of the next 2 years. There are no major shifts anticipated in demand, with galvanizing remaining the largest use. The domestic automobile industry is one of the largest consumers of zinc metal, hence its production rate is a major factor contributing to shifts in the demand pattern. Auto production was predicted to increase 5.7% in 1995 and similarly in 1996. However, increased substitution of plastic and composite materials for die castings and greater use of electrogalvanized steel may reduce the amount the zinc required per vehicle over the next decade. Other uses of galvanized steel, such as framing for residential housing and commercial construction are anticipated to grow substantially in the next decade. Projected growth in demand will keep the United States the largest consumer of zinc in the world.

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[1] Carlin, J. F. USBM Tin MIS 1-31-95, p. 1

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Zinc. Ch. in Mineral Commodity Summaries, annual

Zinc. Reported monthly in Mineral Industry Surveys.

Other Sources

ABMS Nonferrous Metal Data.
American Metal Market.
Engineering and Mining Journal.
Journal of Metals.
Lead and Zinc Statistics (monthly bulletin of ILZSG)
Metal Bulletin (London).
Metals Week.
Mining Journal (London).
The Northern Miner.
World Metal Statistics (WBMS).

TABLE 1
SALIENT ZINC STATISTICS 1/

(Metric tons unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Production:					
Domestic ores, recoverable content	515,000	518,000	523,000	488,000	570,000
Value thousands	$847,000	$602,000	$674,000	$497,000	$619,000
Slab zinc:					
From domestic ores	230,000	218,000	227,000	214,000	201,000
From foreign ores	32,200	35,600	44,800	26,000	15,600
From scrap	95,700	122,000	128,000	141,000	139,000
Total	358,000	376,000	399,000	382,000	356,000
Secondary zinc 2/	246,000	W	W	W	W
Rolled zinc	47,900	41,800	48,200	60,300	53,500
Exports:					
Ores and concentrates (zinc content)	220,000	382,000	307,000	311,000	389,000
Slab zinc	1,240	1,250	565 r/	1,410 r/	6,310
Rolled zinc	11,900	10,400	5,430	6,600	6,680
Imports for consumption:					
Ores and concentrates (zinc content)	46,700	45,400	44,500	33,100	27,400
Slab zinc	632,000	549,000	644,000	724,000	793,000
Rolled zinc	929	537	171	135	475
Stocks of slab zinc, Dec. 31:					
Industry	87,400 r/	79,300 r/	74,900 r/	73,900 r/	71,000
Government stockpile	341,000	344,000	341,000	326,000	286,000
Consumption:					
Slab zinc:					
Reported	802,000	790,000	814,000	828,000 r/	859,000
Apparent 3/	992,000	933,000	1,040,000	1,140,000 r/	1,190,000
All classes 4/	1,240,000	1,170,000	1,280,000	1,350,000 r/	1,420,000
Price: Special High Grade, cents per pound (delivered)	74.59 5/	52.77	58.38	46.15	49.26
World:					
Production:					
Mine thousand metric tons	7,150 r/	7,270 r/	7,260 r/	6,960 r/	6,810 e/
Smelter do.	7,180	7,310	7,230 r/	7,400 r/	7,360 e/
Price: London, cents per pound	66.46 5/	50.67	56.24	43.64	45.26

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits, except prices.

2/ Excludes secondary slab and remelt zinc.

3/ Domestic production plus net imports plus or minus stock changes.

4/ Based on apparent consumption of slab zinc plus zinc content of ores and concentrates and secondary materials.

5/ High grade.

TABLE 2
MINE PRODUCTION OF RECOVERABLE ZINC IN THE UNITED STATES, BY STATE 1/
(Metric tons)

State	1993	1994
Kentucky	(2/)	--
Missouri	40,200	42,000
Montana	W	21,000
Oregon	--	118
Washington	W	--
Other 3/	448,000	507,000
Total	488,000	570,000

W Withheld to avoid disclosing company proprietary data; included in "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Revised to zero.

3/ Includes production from Alaska, Colorado, Idaho, Illinois, New York, Tennessee, and States indicated by symbol "W."

TABLE 3
LEADING ZINC PRODUCING MINES IN THE UNITED STATES IN 1994, IN ORDER OF OUTPUT

Rank	Mine	County and State	Operator	Source of zinc
1	Red Dog	Northwest Arctic, AK	Cominco Alaska Inc.	Zinc ore.
2	Elmwood-Gordonsville	Smith, TN	Savage Zinc Inc.	Do.
3	Balmat	St. Lawrence, NY	Zinc Corporation of America	Do.
4	Young	Jefferson, TN	ASARCO Incorporated	Do.
5	Pierrepont	St. Lawrence, NY	Zinc Corporation of America	Do.
6	Montana Tunnels	Jefferson, MT	Montana Tunnels Mining Inc.	Do.
7	Immel	Knox, TN	ASARCO Incorporated	Do.
8	Leadville Unit	Lake, CO	do.	Do.
9	New Market	Jefferson, TN	do.	Do.
10	Cumberland	Smith, TN	Savage Zinc Inc.	Do.
11	West Fork	Reynolds, MO	ASARCO Incorporated	Lead-zinc ore.
12	Jefferson City	Jefferson, TN	Savage Zinc Inc.	Zinc ore.
13	Clinch Valley	Grainger, TN	do.	Do.
14	Coy	Jefferson, TN	ASARCO Incorporated	Do.
15	Sweetwater	Reynolds, MO	do.	Do.
16	Casteel 1/	Iron, MO	The Doe Run Co.	Lead ore.
17	Fletcher	Reynolds, MO	do.	Do.
18	Buick	Iron, MO	do.	Lead-zinc ore.
19	Rosiclare	Hardin and Pope, IL	Ozark-Mahoning Co.	Fluorspar.
20	Magmont	Iron, MO	Cominco American Inc.	Lead ore.
21	Viburnum No. 29	Washington, MO	The Doe Run Co.	Do.
22	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Lead-zinc ore.
23	Silver Butte	Douglas, OR	Formosa Exploration Inc.	Copper ore.
24	Viburnum No. 28	Iron, MO	The Doe Run Co.	Lead ore.

1/ Includes Brushy Creek Mill.

TABLE 4
PRIMARY AND SECONDARY SLAB ZINC PRODUCED IN THE UNITED STATES 1/

(Metric tons)

	1993	1994
Primary:		
From domestic ores	214,000	201,000
From foreign ores	26,000	15,600
Total	240,000	217,000
Secondary:		
At primary smelters	99,300	99,900
At secondary smelters	42,200	39,200
Total	141,000	139,000
Grand total (excludes zinc recovered by remelting)	382,000	356,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 5
DISTILLED AND ELECTROLYTIC ZINC, PRIMARY AND SECONDARY, PRODUCED IN THE UNITED STATES, BY GRADE 1/

(Metric tons)

Grade	1993	1994
Special High	104,000	119,000
High	89,900	31,100
Continuous Galvanizing	65,400	62,000
Controlled Lead	7,570	2,670
Prime Western	115,000	141,000
Total	382,000	356,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 6
SLAB ZINC CAPACITY OF PRIMARY ZINC PLANTS IN THE UNITED STATES, BY TYPE OF PLANT AND COMPANY

(Metric tons)

Type of plant and company	Slab zinc capacity 1993	Slab zinc capacity 1994
Electrolytic:		
Big River Zinc Corp., Sauget, IL	82,000	82,000
Savage Zinc, Inc., Clarksville, TN	98,000	98,000
Zinc Corp. of America, Bartlesville, OK 1/	54,000	54,000
Electrothermic:		
Zinc Corp. of America, Monaca, PA 2/	146,000	146,000
Total available capacity	380,000	380,000
Total operating capacity	326,000	326,000

1/ Temporarily closed in Sept. 1993.

2/ Includes secondary capacity.

TABLE 7
U.S. CONSUMPTION OF ZINC 1/

(Metric tons)

	1993 r/	1994
Slab zinc, apparent	1,140,000	1,190,000
Ores and concentrates (zinc content) 2/	W	W
Secondary (zinc content) 3/	W	W
Total	1,350,000	1,420,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Includes ore used directly in galvanizing.

3/ Excludes secondary slab zinc.

TABLE 8
U.S. REPORTED CONSUMPTION OF SLAB ZINC IN 1994, BY INDUSTRY USE AND GRADE 1/

(Metric tons)

Industry use	Special High Grade	High Grade	Prime Western	Remelt and other grades	Total
Galvanizing	89,100	76,600	162,000	66,600	395,000
Zinc-base alloys	196,000	W	W	--	196,000
Brass and bronze	46,400	W	W	W	107,000
Zinc oxide	W	W	--	--	68,300
Other	W	W	W	W	92,400
Total	486,000	112,000	192,000	68,400	859,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

TABLE 9
ZINC CONTENT OF PRODUCTION AND SHIPMENTS OF ZINC PIGMENTS AND COMPOUNDS 1/ IN THE UNITED STATES 2/

(Metric tons)

	1993		1994	
	Production	Shipments	Production	Shipments
Zinc chloride 3/	4,240	4,240	9,170	9,170
Zinc oxide	102,000	102,000	106,000	105,000
Zinc sulfate	20,500	19,900	22,700	22,000

1/ Excludes leaded zinc oxide and lithopone.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

3/ Includes zinc content of zinc ammonium chloride.

TABLE 10
REPORTED DISTRIBUTION OF ZINC CONTAINED IN ZINC OXIDE SHIPMENTS, BY COUNTRY 1/ 2/

(Metric tons)

Industry	1993	1994
Agriculture	1,580	1,900
Ceramics	W	W
Chemicals	W	W
Paints	3,420	3,550
Photocopying	W	W
Rubber	65,300	65,600
Other	3,110	1,480
Total	102,000	105,000

W Withheld to avoid disclosing company proprietary data; included in "Other."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ In addition, zinc oxide was imported as follows: 1993--35,900; 1994--41,300; distribution cannot be distinguished by industry.

TABLE 11
U.S. EXPORTS OF ZINC ORES AND CONCENTRATES, BY COUNTRY 1/

(Zinc content)

	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	48,600	22,000	86,700	36,100
Canada	110,000	35,900	147,000	67,600
Finland	14,800	3,990	--	--
Germany	33,300	13,900	30,200	12,600
Japan	68,800	26,700	68,400	24,500
Korea, Republic of	6,160	2,560	11,700	4,850
Russia	9,950	1,990	9,990	2,200
Spain	7,930	2,100	9,660	2,210
United Kingdom	10,600	7,070	1	3
Other	911	953	26,000	6,550
Total	311,000	117,000	389,000	157,000

1/ Previously publised and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 12
U.S. EXPORTS OF ZINC COMPOUNDS 1/

	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Lithopone	216	$436	426	$393
Zinc chloride	1,140	947	947	939
Zinc compounds, n.s.p.f.	5,490	31,100	8,530	13,300
Zinc oxide	5,460	7,250	8,200	7,190
Zinc sulfate	4,760	8,830	5,230	8,500
Zinc sulfide	219	1,840	2,000	792

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF ZINC PIGMENTS AND COMPOUNDS 1/

	1993		1994	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Lithopone	1,140	$696	1,110	$857
Zinc chloride	3,580	3,300	3,360	2,960
Zinc compounds, n.s.p.f.	312	686	225	519
Zinc oxide	35,900	40,500	41,300	45,800
Zinc sulfate	5,620	3,110	7,200	4,000
Zinc sulfide	2,050	4,970	1,950	5,530

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 14
ZINC: WORLD MINE PRODUCTION (CONTENT OF CONCENTRATE AND DIRECT SHIPPING ORE UNLESS NOTED), BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Algeria	4,160	2,610	7,500 r/ e/	6,800 r/ e/	6,800
Argentina	38,700	39,300	41,000	31,400 r/	33,000
Australia	940,000	1,020,000	1,030,000 r/	1,010,000 r/	995,000
Austria	16,700	14,800	13,500	5,400 e/	--
Bolivia	104,000	130,000	144,000	123,000	101,000
Bosnia and Herzegovina e/	XX	XX	3,000	600	600
Brazil	158,000	130,000	149,000 r/	172,000 r/	172,000
Bulgaria	34,700	29,100	29,000 e/	25,000 e/	25,000
Burma	1,580	996 r/	1,080 r/	850 r/	1,800
Canada	1,200,000	1,160,000	1,320,000	1,010,000	984,000 3/
Chile	25,100	31,000	29,700	29,400 r/	30,000
China e/	619,000	750,000	758,000 r/	775,000 r/	780,000
Colombia	356	266	277	279	275
Czech Republic e/	XX	XX	XX	1,500 r/	100 3/
Czechoslovakia e/ 4/	9,800	11,600	7,500	XX	XX
Ecuador e/	100	100	100	100	100
Finland	51,700 e/	55,500	30,800	22,000 r/	16,900 3/
France	23,900	27,100	16,500	13,800 r/	1,000
Georgia e/	XX	XX	2,000	1,500	1,000
Germany: Western states	58,200	54,000	14,300	--	--
Greece	26,700	30,000	26,000	22,000 r/	20,000
Greenland	47,900	--	--	--	--
Honduras	29,600	38,300	29,000 r/	18,300 r/	16,700 3/
India	74,000	105,000 r/	153,000 r/	156,000 r/	144,000 3/
Iran	29,000 e/	70,000 e/	66,000 r/	77,000 r/	75,000
Ireland	167,000	188,000	194,000 r/	194,000 r/	195,000
Italy	43,000	36,300	35,000	7,100 r/	6,000
Japan	127,000	133,000	135,000	119,000	101,000 3/
Kazakhstan e/	XX	XX	250,000	250,000	175,000
Korea, North e/	230,000	200,000	200,000	210,000	210,000
Korea, Republic of	22,800	22,000	21,900	27,600 r/	25,000
Macedonia e/	XX	XX	16,000	16,000	16,000
Mexico	307,000	317,000	294,000	370,000	382,000 3/
Morocco	18,800	24,300	22,600	65,400 r/	77,000
Namibia	37,700	33,200	36,100	28,400	33,400 3/
Norway	17,500	18,900	21,100	14,300 r/	15,600 3/
Peru	598,000 r/	638,000 r/	605,000 r/	664,000 r/	665,000
Philippines	53	--	--	--	--
Poland	153,000 r/	145,000 r/	152,000 r/	152,000 r/	151,000
Romania	36,000	26,900	25,000	28,000 e/	25,000
Russia e/	XX	XX	150,000	170,000	140,000
Saudi Arabia	2,470	2,480	2,480 e/	2,500 e/	2,500
Serbia and Montenegro e/	XX	XX	19,700 r/	9,700 r/	8,000
Slovakia e/	XX	XX	XX	3,100	3,000
Slovenia	XX	XX	1,550	--	--
South Africa, Republic of	74,800	64,400	71,900	77,100 r/	76,400 3/
Spain	258,000	261,000 e/	205,000 r/	170,000 r/	150,000 3/
Sweden	164,000	161,000	172,000 r/	169,000 r/	160,000 3/
Thailand	61,500	87,000	62,000 e/	70,000 e/	56,000
Tunisia	7,000	5,000	4,090	2,400 r/	26,500 3/
Turkey 5/	39,100	32,500	32,500 r/	32,500 e/	35,000
U.S.S.R. e/ 6/	550,000	475,000	XX	XX	XX
United Kingdom	6,670	1,080	--	--	--
United States	543,000	547,000	552,000	513,000	598,000 3/
Uzebekistan e/	XX	XX	60,000	60,000	55,000
Vietnam e/	10,000	15,000	15,000	15,000	15,000
Yugoslavia 7/	83,800	75,000 e/	XX	XX	XX
Zaire	61,800	42,400	22,300	6,500 e/	6,500
Zambia 8/	32,100	19,800	14,700 r/	16,700 r/	--
Total	7,150,000 r/	7,270,000 r/	7,260,000 r/	6,960,000 r/	6,810,000

See footnotes at end of table.

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 5, 1995.

3/ Reported figure.

4/ Dissolved Dec. 31, 1992.

5/ Content in ore hoisted.

6/ Dissolved in Dec. 1991.

7/ Dissolved in Apr. 1992.

8/ Data are for years beginning Apr. 1 of that stated. Content of ore milled. Mine closed June 1994.

TABLE 15
ZINC: WORLD SMELTER PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Algeria, primary	23,600	24,900	31,000 e/	31,000 e/	35,000
Argentina:					
Primary	31,500	35,800	34,500	35,000 e/	34,500
Secondary e/	2,700	2,800	2,800	2,800	2,700
Total	34,200	38,600	37,300	37,800 e/	37,200
Australia:					
Primary 3/	304,000	322,000	333,000 r/	316,000 r/	326,000
Secondary e/	4,500	4,500	4,500	4,500	4,500
Total e/	309,000	327,000	338,000 r/	321,000 r/	331,000
Austria, primary and secondary	26,900 r/	15,900 r/	5,540 r/	6,820 r/	–
Belgium, primary and secondary	357,000	385,000	311,000	300,000 r/	310,000
Brazil:					
Primary	150,000	157,000 r/	180,000 r/	188,000 r/	190,000
Secondary	4,600	5,540 r/	7,000 r/	7,200 r/	7,000
Total	154,000	163,000	187,000 r/	195,000 r/	197,000
Bulgaria, primary and secondary	75,500	58,700	47,000	47,000 e/	45,000
Canada, primary	592,000	661,000	672,000	662,000	693,000 6/
China, primary and secondary e/	550,000	612,000	719,000	857,000 r/	975,000
Czechoslovakia, secondary 4/ 5/	1,000	800	1,100	XX	XX
Finland, primary	175,000	170,000	171,000	171,000 r/	173,000
France, primary and secondary	263,000	300,000	319,000 r/ e/	310,000 r/ e/	310,000
Germany:					
Eastern states, primary and secondary	12,700	XX	XX	XX	XX
Western states:					
Primary	288,000 r/	XX	XX	XX	XX
Secondary	49,900 r/	XX	XX	XX	XX
Total	350,000	346,000	383,000	381,000 r/	360,000 6/
Hungary, secondary e/	1,300	1,300	1,000	1,000	1,000
India:					
Primary	79,100	85,800	128,000 r/	142,000 r/	143,000 6/
Secondary e/	200	200	200	200	500
Total e/	79,300	86,000	128,000 r/	142,000 r/	144,000
Italy, primary and secondary	264,000	264,000	253,000	254,000 r/ e/	260,000
Japan:					
Primary	606,000	641,000	645,000	609,000 r/	572,000 6/
Secondary	126,000	138,000	136,000	135,000 r/	141,000 6/
Total	732,000	779,000	781,000	745,000 r/	713,000 6/
Kazakhstan, primary e/	XX	XX	250,000	250,000	175,000
Korea, North, primary e/	200,000	175,000	175,000	200,000	200,000
Korea, Republic of, primary	248,000	254,000	253,000	272,000	250,000
Macedonia, primary and secondary e/	XX	XX	32,000	32,000	32,000
Mexico, primary	199,000	189,000	152,000	210,000	220,000
Netherlands, primary 7/	209,000	211,000	210,000	207,000	210,000
Norway, primary	125,000	125,000	128,000	129,000 r/	132,000 6/
Peru, primary	121,000	155,000	138,000 r/	165,000 r/	165,000
Poland, primary and secondary	132,000	126,000	135,000	150,000 r/	156,000
Portugal, primary e/	5,500	2,100	2,200 r/	2,800	3,000
Romania, primary and secondary e/	11,500	8,700	11,600	14,000 r/	18,500
Russia: e/					
Primary	XX	XX	140,000	140,000	115,000
Secondary	XX	XX	60,000	60,000	50,000
Total	XX	XX	200,000	200,000	165,000

See footnotes at end of table.

TABLE 15--Continued
ZINC: WORLD SMELTER PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1990	1991	1992	1993	1994 e/
Serbia and Montengero, primary and secondary	XX	XX	14,200	17,000 r/	3,900 7/
Slovakia, secondary 5/	XX	XX	XX	1,000 e/	1,000
Slovenia, primary and secondary e/	XX	XX	2,500	2,500	2,500
South Africa, Republic of, primary	91,900	91,700	83,200	96,200 r/	93,900 6/
Spain, primary and secondary	253,000	262,000	366,000	328,000 r/	325,000
Thailand, primary	63,300	62,200	60,600 r/	65,000 r/ e/	68,000
Turkey, primary	20,100	17,400	18,800 r/	17,000 r/	18,500 6/
Ukraine, secondary e/	XX	XX	15,000 r/	12,000	10,000
U.S.S.R.: e/ 8/					
Primary	780,000	700,000	XX	XX	XX
Secondary	110,000	100,000	XX	XX	XX
Total	890,000	800,000	XX	XX	XX
United Kingdom, primary and secondary	93,300	101,000	96,800	102,000 r/	96,800 6/
United States:					
Primary	263,000	253,000	272,000	240,000	217,000 6/
Secondary	95,700	123,000	128,000	142,000	139,000 6/
Total	358,000	376,000	400,000	382,000	356,000 6/
Uzbekistan, primary e/	XX	XX	65,000	65,000	60,000
Vietnam, primary and secondary e/	10,000	10,000	10,000	10,000	10,000
Yugoslavia, primary and secondary 9/	114,000	78,000	XX	XX	XX
Zaire, primary	38,200	28,300	18,800	4,000 e/	4,000
Zambia, primary 10/	9,720 r/	6,340 r/	7,290 r/	3,450 r/	-- 6/
Total primary	4,620,000	4,370,000	4,170,000 r/	4,220,000 r/	4,100,000
Total secondary	396,000 r/	376,000	355,000 r/	365,000 r/	357,000
Total undifferentiated	2,160,000	2,570,000	2,700,000 r/	2,810,000 r/	2,900,000
Grand total	7,180,000	7,310,000	7,230,000 r/	7,400,000 r/	7,360,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Wherever possible, detailed information on raw material source of output (primary--directly from ores, and secondary--from scrap) has been provided. In cases where raw material source is unreported and insufficient data are available to estimate the distribution of the total, that total has been left undifferentiated (primary and secondary). To the extent possible, this table reflects metal production at the first measurable stage of metal output. Table includes data available through July 5, 1995.

3/ Excludes zinc dust.

4/ All production in Czechoslovakia from 1990-92 came from Slovakia.

5/ Dissolved Dec. 31, 1992.

6/ Reported figure.

7/ Sales.

8/ Dissolved in Dec. 1991.

9/ Dissolved in Apr. 1992.

10/ Data are for years beginning Apr. 1 of that stated. Imperial smelter production ceased in Mar. 1993. Electrolytic production was suspended Jan. 1991 to Mar. 1993 and ceased in Jan. 1994.

ZIRCONIUM AND HAFNIUM

By Joseph M. Gambogi

Zirconium and hafnium are relatively abundant in the Earth's crust, however, zircon (zirconium silicate) is the only naturally occurring mineral of commercial significance. Zirconium and hafnium are both contained in zircon at a ratio of about 50 to 1. Zircon is a byproduct of the mining and processing of heavy mineral sands for the titanium minerals rutile and ilmenite. The major end uses of zircon are refractories, foundry sands (including investment casting), and ceramic opacification.

World zircon production was estimated to have increased significantly in 1994. Worldwide, zircon consumption was estimated to have increased by 4%. The growth in demand for zircon was primarily attributed to increased consumption by the ceramic tile industry. In response to increased demand and a limited supply of material, prices for zircon concentrates increased moderately.

U.S. production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data. Domestic production of milled zircon increased 14% in 1994. According to U.S. Customs trade statistics, the United States was a net importer of zircon, and imports of zircon increased 17%.

With the exception of prices, all data in this report have been rounded to three significant digits. Totals and percentages were calculated from unrounded numbers.

Production

Data for zirconium and hafnium materials are developed by the U.S. Bureau of Mines from one voluntary survey of domestic operations. Of the 33 operations surveyed, 23 responded, representing 75% of the domestic production data in table 1. Data for nonrespondents were estimated based on prior year levels. Domestic production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data. Milled zircon production increased 14% from that of 1993, while zirconium oxide production increased 21% from the revised 1993 level. *(See table 1.)*

U.S. mine producers of zircon in 1993 were RGC (USA) Mineral Sands, Inc., and E. I. du Pont de Nemours & Co. Inc. (Du Pont). Both producers mined heavy mineral sand deposits in Florida.

Prices

Countless end products were produced from zircon. High-volume production included refractory bricks and shapes, alumina-zirconia abrasives, foundry sands and investment castings, milled and micronized zircon, zirconium chemicals, and zirconia. Examples of high-unit-value products include cubic zirconia, technical zirconia ceramics, superalloy castings, zirconia textile refractories, and specialty chemicals. Zirconium-clad fuel rods and hafnium control rods make up the core of nuclear reactors. Commercial-grade zirconium, unlike nuclear grade, contains hafnium and is used in the chemical process industries because of its excellent corrosion resistance. Increased demand from the ceramic industry caused prices of zircon-base concentrates to increase by about 10% from the 1993 level. However, published prices for zirconium, hafnium, and zirconia-base products were reportedly unchanged. *(See table 2.)*

Foreign Trade

In 1994, the United States was a net importer of zircon. The two leading import sources were Australia and South Africa. Imports of zircon increased about 17% from those of 1993. The United States is a net exporter of zirconium and hafnium metal. Mexico and Germany were the largest importers of domestic zirconium. Exports of zirconium decreased about 11% compared with those of 1993.

World Review

Australia.—Cable Sands Ltd. commissioned its Jangarup mineral sands operation near Nannup, Western Australia. The operation was expected to produce 230,000 tons per year of heavy mineral concentrate.[1]

In March, production from one of Consolidated Rutile Ltd.'s (CRL) mineral sands operations on North Stradbroke Island was temporarily interrupted when a 450-ton dredge sank.[2] CRL's other dredge on North Stradbroke Island was not affected, and the repaired dredge was put back into operation in May.

Hanwah Corp. purchased ICI Australia's zirconia plant at Rockingham, Western Australia. Although the plant has been idle since 1992, the plant was designed to produce 450 tons per year of high-purity zirconia. Hanwah planned to recommission the plant in 1995.[3]

Canada.—Tiomin Resources Inc. completed a prefeasibility review of its Natashquan mineral sands project in Quebec. The review concluded the project was feasible, and the company was seeking joint-venture partners to develop the project.[4]

China.—CRL entered into a joint venture with the Wujin County Third Building Co. to produce micronized zircon at a new facility located Xiaxi, Jiangsu Province. Construction of a new 3,000-ton-per-year plant began in June, and the plant was expected to be commissioned in March 1995.[5]

Russia.—Seamet Ltd. entered into a joint venture with a Russian partner for the development of the Tsentralnoye mineral sands deposit in southern Russia. The deposit is reported to contain proven reserves of 2.25 million tons of heavy minerals.[6]

South Africa.—Anglo-American Corp.'s subsidiary, Namakwa Sands Ltd., commissioned mining operations at Brand-se-Baai on the west coast of South Africa. When completed, the project was expected to produce 120,000 tons of zircon annually.

United Kingdom.—Titanium dioxide producer Tioxide PLC moved into the advanced ceramics market as a supplier of zirconia. Tioxide plans to market three grades of zirconia based on a gas-phase process that allows the formation of zirconia crystals in one step. The new operation was incorporated into Tioxide's Billingham facility.[7]

Outlook

Growth in demand for zircon materials is being led by its use as an opacifier in glazed ceramic tile manufacture. Zircon consumption has been forecast to reach more than 1 million tons by the year 2000. By the end of the century, consumption in the ceramics industry is forecast to be about 50% of total consumption. Although Australia is expected to continue as a major supplier of zircon, South Africa should overtake Australia as the leading producer of zircon concentrates.[8]

OTHER SOURCES OF INFORMATION

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Industrial Minerals (London), monthly.
International Strategic Minerals Inventory. U.S. Geological Survey, Circular 30-L.
Metal Bulletin (London), semiweekly.
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Mining Engineering, monthly.
Mining Journal.
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Roskill Information Services Ltd. (London). The Economics of Zirconium, 7th edition, 1992.

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[1] Industrial Minerals. Jangarup Enters Production. No. 322, July 1994, p. 74.

[2] Mining Journal. Cons. Rutile Dredger Sinks. Apr. 29, 1994, p. 311.

[3] Industrial Minerals. ICI Sells Zirconia Plant. No. 326, Nov. 1994, p. 8.

[4] ———. Tiomin Minsands Project Advances. No. 322, Aug. 1995, p.11.

[5] ———. CRL Zircon Opacifier JV. No. 327, Dec. 1994, p. 9.

[6] ———. Australian Interest in Tambov Mineral Sands. No. 327, Dec. 1994, p. 11.

[7] ———. Tioxide Develops Zirconia Business. No. 316, Feb. 1994, p. 19.

[8] ———. Shifts in Zircon Supply and Demand. No. 322, Aug. 1994, p. 17.

TABLE 1
SALIENT U.S. ZIRCONIUM STATISTICS 1/

(Metric tons)

	1990	1991	1992	1993	1994
Zircon:					
Production:					
Concentrates	102,000	103,000	108,000	W	W
Milled zircon	43,900	44,400	45,100	46,700	53,300
Exports	30,200	31,300	27,900	35,900	32,000
Imports for consumption 2/	26,800	35,700	37,400	70,000	82,000
Consumption, apparent 2/	103,000	111,000	121,000 r/	W	W
Stocks, Dec. 31: Dealers and consumers 3/	28,100	24,400	21,600	26,000	30,100
Zirconium oxide:					
Production 4/	7,480	9,750	8,690	10,000 r/	12,100
Exports 5/	NA	NA	NA	1,280	1,220
Imports for consumption 5/	NA	NA	NA	1,990	2,400
Consumption, apparent	NA	NA	NA	W	W
Stocks, Dec. 31: Producer 4/	737	872	719	W	W

r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Includes insignificant amounts of baddeleyite.

3/ Excludes foundries.

4/ Excludes intermediate oxides associated with metal production.

5/ Includes germanium oxides and zirconium dioxides.

TABLE 2
PUBLISHED YEAREND PRICES OF ZIRCONIUM AND HAFNIUM MATERIALS

Specification of material	1993	1994
Zircon:		
Domestic, standard-grade, f.o.b. Starke, FL, bulk, per short ton 1/	$265.00	$278.00
Domestic, 75% minimum quantity zircon and aluminum silicates, Starke, FL, bulk, per short ton 1/	242.00	254.00
Domestic, premium grade zircon, Starke, FL, bulk, per short ton 1/	294.00	309.00
Imported sand, ceramic application, f.o.b., bulk, per metric ton 2/	$210.00 - 220.00	$230.00 - 240.00
Imported sand, refractory application, f.o.b., bulk, per metric ton 2/	210.00 - 220.00	230.00 - 240.00
Imported sand, foundry sand application, f.o.b., bulk, per metric ton 2/	190.00 - 210.00	210.00 - 230.00
Baddeleyite, imported concentrate: 3/		
98% to 99% ZrO_2, minus 100-mesh, c.i.f. Atlantic ports, per pound	.75 - .85	.82 .88
99%+ ZrO_2, minus 325-mesh, c.i.f. Atlantic ports, per pound	1.07 r/	1.13
Zirconium oxide: 4/		
Powder, commercial grade, drums, 2,000-pound minimum, per pound	3.00 - 6.60	3.00 - 6.60
Electronic, same basis, per pound	3.50 - 8.00	3.50 - 8.00
Insulating, stabilized, 325° F, same basis, per pound	3.35 - 4.00	3.35 - 4.00
Insulating, unstabilized, 325° F, same basis, per pound	3.35 - 4.00	3.35 - 4.00
Dense, stabilized, 300° F, same basis, per pound	3.60	3.60
Zirconium: 5/		
Powder, per pound	75.00 - 150.00	75.00 - 150.00
Sponge, per pound	9.00 - 12.00	9.00 - 12.00
Sheets, strip, bars, per pound	20.00 - 50.00	20.00 - 50.00
Hafnium: Sponge, per pound 5/	75.00 - 95.00	75.00 - 95.00

r/ Revised.

1/ E. I. du Pont de Nemours & Co. Inc. price list, July 1, 1993 and July 1, 1994, respectively.

2/ Industrial Minerals (London). No. 316, Jan. 1994, p.71; and No. 327, Dec. 1994, p. 63.

3/ The Applegate Group and American Vermiculite Corp. baddeleyite price lists.

4/ Chemical Marketing Reporter. V. 244, No. 26, Dec. 27, 1993; v. 247, No. 1, Jan. 2, 1995.

5/ American Metal Market. V. 101, No. 233, Dec. 3, 1993, p. 7; and v. 102, No. 232, Dec. 2, 1994, p. 6.

TABLE 3
U.S. EXPORTS OF ZIRCONIUM, BY CLASS AND COUNTRY 1/

Class and country	1993 Quantity (metric tons)	1993 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Ore and concentrates:				
Argentina	567	$312	277	$155
Brazil	672	167	1,210	290
Canada	2,750	2,020	3,860	2,190
China	135	152	565	404
Colombia	1,710	1,230	2,350	1,580
Dominican Republic	175	173	--	--
Ecuador	195	59	153	92
France	462	228	660	291
Germany	15,300	3,390	5,940	1,930
Hong Kong	310	249	--	--
Indonesia	309	201	175	114
Japan	232	129	223	239
Korea, Republic of	112	43	113	600
Malaysia	253	167	175	123
Mexico	8,460	2,110	9,300	2,790
Netherlands	176	83	2,320	580
Pakistan	199	123	176	122
Singapore	526	320	488	314
Taiwan	577	420	576	382
United Kingdom	896	418	630	323
Venezuela	1,560	922	1,390	926
Other	385 r/	261 r/	1,450	466
Total	35,900	13,200	32,000	13,900
Unwrought zirconium and waste and scrap:				
Japan	123	3,570	119	4,630
Other	125 r/	2,580 r/	104	1,940
Total	248	6,150	223	6,570

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF ZIRCONIUM AND HAFNIUM, BY CLASS AND COUNTRY 1/

Class and country	1993 Quantity (metric tons)	1993 Value (thousands)	1994 Quantity (metric tons)	1994 Value (thousands)
Zirconium ore and concentrates: 2/				
Australia	37,000	$5,220	45,500	$6,960
South Africa, Republic of	32,200	3,580	35,800	6,850
Other	815 r/	528 r/	714	1,070
Total	70,000	9,320	82,000	14,900
Zirconium, unwrought and waste and scrap:				
Canada	--	--	57	58
France	33	233	28	198
Germany	16	338	49	637
Japan	64	447	29	42
Other	8	147	25	175
Total	121	1,170 r/	188	1,110
Hafnium, unwrought and waste and scrap:				
Canada	(3/)	2	--	--
France	3	556	4	783
Germany	(3/)	104	(3/)	86
United Kingdom	(3/)	7	(3/)	2
Total	3	669	5	871

r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Australia and the Republic of South Africa are believed to be point of origin; other countries are point of shipment.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

CEN

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